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John THE *Jackson's Book*
Religious Philosopher :

Or, the Right USE of
 Contemplating the Works of the
CREATOR.

- I. In the wonderful Structure of Animal Bodies, and in particular M A N.
- II. In the no less wonderful and wise Formation of the ELEMENTS, and their various Effects upon Animal and Vegetable Bodies. And,
- III. In the most amazing Structure of the HEAVENS, with all its Furniture;
 DESIGNED
For the Conviction of ATHEISTS and INFIDELS.

V O L. II.

Throughout which, all the late DISCOVERIES in *Anatomy, Philosophy and Astronomy*, together with the various Experiments made use of to illustrate the same, are most copiously handled by that Learned *Mathematician*, Dr. NIEUWENTYT.

Translated from the Original,
 By JOHN CHAMBERLAYNE, *Esq*; F. R. S.

Adorn'd with CUTS.

L O N D O N :

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 and will be finish'd in a short time.



OF THE USE OF
THE
CONTAINING THE WORKS OF THE
CONTENTS

- I. In the wonderful Structure of Animal Bodies, and in particular MAN.
 - II. In the wonderful Structure of the Elements, and their various Effects upon Animal and Vegetable Bodies. And
 - III. In the most amazing Structure of the
- DESIGNED
For the Convenience of Astronomers and Philosophers.

VOL. II.

CONTENTS
The various Elements, and their various Effects upon Animal and Vegetable Bodies. And

Sec. IV. An Experiment concerning the Gravity of the

Sec. V. and VI. The Effects of the Earth's Gravity upon

Sec. VII. The Effects of the Earth's Gravity upon



THE
CONTENTS
OF THE
Second VOLUME
OF
Dr. Nieuwentyt's Contemplations.

CONTEMPLATION XVII. *Page 367.*
Of the AIR.

Sect. I.  *Ranftion to the Contemplation of the World.*

Sect. II. *And firft of the Air.*

Sect. III. *The Gravity and Elasticity of Air.*

Sect. IV. *An Experiment concerning the Gravity of the Air.*

Sect. V, and VI. *The Air's Elastic Faculty prov'd Experimentally.*

Sect. VII. *The Pressure of the Air.*

The C O N T E N T S.

- Sect. VIII. *The Mistakes of some Atheists.*
- Sect. IX. *A Description of Barometers, &c.*
- Sect. X. *A Barometer made of Water and Lie, with some Experiments.*
- Sect. XI. *The prodigious Pressure of the Air upon a Man.*
- Sect. XII. *Convictions from the foregoing Observations.*
- Sect. XIII, and XIV. *Other Experiments proving the Pressure of the Air.*
- Sect. XV. *Convictions from the foregoing Observations.*
- Sect. XVI. *A little Air resists a greater Quantity.*
- Sect. XVII. *A little Air gravitates as strongly as a great deal of Air.*
- Sect. XVIII. *The Difference between the Gravity and Elasticity of the Air.*
- Sect. XIX. *How the Elastic Power of the Air works by the Gravity thereof.*
- Sect. XX. *The Air that bears most Weight is most compress'd.*
- Sect. XXI. *Air that is most Compressed is most Elastic.*
- Sect. XXII. *Convictions from the foregoing Observations.*
- Sect. XXIII, and XXIV. *The Elastic Power of the Air is the Cause of Suction, proved Experimentally.*
- Sect. XXV. *Convictions from the foregoing Observations.*
- Sect. XXVI. *Experiments to shew that Living Creatures will perish in a Place from which the Air is exhausted.*
- Sect. XXVII. *Atheists deny their own Principles.*
- Sect. XXVIII. *To die in an Unelastical Air is no necessary Consequence of Nature.*
- Sect. XXIX. *To die therefore in an Air divested of its Elasticity is only the result of the Will of G O D.*

The C O N T E N T S.

- Sect. XXX. *The Elastic Faculty of the Air is not sufficient alone for the Preservation of Life.*
- Sect. XXXI. *The Elastic Power of the Air does likewise cause Fish to live and subsist under Water.*
- Sect. XXXII. *Plants do also live by Air.*
- Sect. XXXIII. *Fire is supported by Air.*
- Sect. XXXIV. *Air causes Smoak and the Particles thereof to ascend.*
- Sect. XXXV. *Air is the Cause of Sounds.*
- Sect. XXXVI, and XXXVII. *Several Experiments of the Productions of Sounds by Air.*
- Sect. XXXVIII. *Convictions from the foregoing Observations.*
- Sect. XXXIX. *The Use of Air in Pumps.*
- Sect XL. *The Air contains fermenting Humours in Vessels.*
- Sect. XLI. *About Refraction and Twilight.*
- Sect. XLII. *Convictions from the foregoing Observations.*
- Sect. XLIII. *The Gravity and Elasticity of the Air unknown to the Ancients.*

CONTEMPLATION XVIII. Page 414.

of M E T E O R S.

- Sect. I. *Transign to the Meteors.*
- Sect. II. *The Air is a Menstruum or dissolving Fluid.*
- Sect. III. *The Air is impregnated with a great Variety of Particles.*
- Sect. IV. *The same proved in Sulphureous Particles.*
- Sect. V. *The like Mixture with Particles of Fire.*
- Sect. VI. *Alcalis and Acids mix'd with Air.*
- Sect. VII. *Burning Spirits and Oyls mix themselves with the Air.*
- Sect. VIII. *Other Particles do likewise mix themselves with the Air.*
- Sect. IX. *Many Particles preserve their Properties in the Air.*
- Sect.

The C O N T E N T S.

- Sect. X. *The aforementioned different Particles by acting on each other do produce both wholesome and unwholesome Airs.*
- Sect. XI, and XII. *Several Experiments proving the same.*
- Sect. XIII. *Convictions from the foregoing Observations.*
- Sect. XIV. *The Invisibilty and Insipidity of the Air is very useful.*
- Sect. XV. *The Observation of Meteors resumed.*
- Sect. XVI, and XVII. *Mists and Fogs produced by many Exhalations, and by the Rarification of the Air prov'd Experimentally.*
- Sect. XVIII. *Reflections and Observations upon the same.*
- Sect. XIX. *An Experiment to shew that Mists and Fogs may be produced by Effervescences.*
- Sect. XX. *An Experiment proving the like Effect by Precipitations or Separations.*
- Sect. XXI. *Fogs are Clouds.*
- Sect. XXII. *Wind and its Usefulness, and Convictions from thence.*
- Sect. XXIII. *The Trade Winds and Monsoons.*
- Sect. XXIV. *Convictions from the foregoing Observations.*
- Sect. XXV. *A Brief Description of the abovemention'd Winds.*
- Sect. XXVI. *Transition to Experiments about the possible Causes of Wind.*
- Sect. XXVII. *The First Experiment touching the Contractions of the Space in which the Air is contained.*
- Sect. XXVIII. *The Second Experiment with the hollow Globe.*
- Sect. XXIX. *The Third Experiment ; the Moving of solid Bodies by the Air.*
- Sect. XXX. *The Fourth Experiment, Effervescences,*

THE CONTENTS.

- Sect. XXXI. *The Fifth Experiment, by burning Sulphureous Bodies and Salt-Petre together.*
- Sect. XXXII. *The Sixth Experiment, shewing that the Elastic Power of the Air being augmented, produces Winds.*
- Sect. XXXIII. *The Seventh Experiment; the Diminution or Weakening of the Air will produce the same Effect.*
- Sect. XXXIV. *The Eighth Experiment, of producing Wind by Cold.*
- Sect. XXXV. *The Ninth Experiment of Wind produced by Warmth.*
- Sect. XXXVI. *The Tenth Experiment; Wind produced by the Suspension or Cessation of Warmth.*
- Sect. XXXVII. *The Eleventh Experiment; Wind produced by the Motion of the Air upwards.*
- Sect. XXXVIII. *Convictions from what has been represented about the Air in general.*
-

CONTEMPLATION XIX. Page 461.

OF WATER.

- Sect. I. *Without Water every Thing would die with Thirst.*
- Sect. II. *Convictions from thence.*
- Sect. III. *Without Water ever living Creature would likewise dye with Hunger.*
- Sect. IV. *Experiments proving that Plants consist for the most part of nothing but Water.*
- Sect. V. *It is not here consider'd, whether Water be a simple or compound Body.*
- Sect. VI. *Convictions from the foregoing Observations.*
- Sect. VII. *An Experiment to shew that Water chang'd into Earth.*
- Sect. VIII. *Other Experiments proving the same.*

Sect.

The C O N T E N T S.

- Sect. IX. *That living Creatures, Plants, Minerals, and even Metals themselves, are produced from Water, shewn Experimentally.*
- Sect. X. *The Ascent of the Water into the Air.*
- Sect. XI. *How such Ascent happens.*
- Sect. XII. *Experiments proving that Air adheres to other Bodies.*
- Sect. XIII. *Experiments to prove that Fire will cleave to solid Bodies.*
- Sect. XIV. *Fire will also cleave to Water, proved Experimentally.*
- Sect. XV. *Three Consequences from the last Experiment.*
- Sect. XVI. *Water and Fire produce a Composition lighter than Air.*
- Sect. XVII. *Water must be divided into exceeding small Particles in order to be evaporated.*
- Sect. XVIII. *Vapours ascend both by Heat and Cold.*
- Sect. XIX. *The Laws of Hydrostaticks.*
- Sect. XX, and XXI. *The Vapors in the Air adapt themselves to these Hydrostatical Laws ; shewn by several Experiments.*
- Sect. XXII. *How Vapours float in the Air.*
- Sect. XXIII. *Experiments shewing how Vapours can descend.*
- Sect. XXIV. *Vapours descend by the Separation of the Particles of Fire from them.*
- Sect. XXV. *Experiments proving the Descent of Vapours by Airs becoming lighter.*
- Sect. XXVI. *Cold produces the same Effect, shewn Experimentally.*
- Sect. XXVII. *The Motion of Vapours from one Place to another is necessary.*
- Sect. XXVIII. *An Experiment proving that the watry Vapors leave their Salts behind them.*
- Sect. XXIX. *If the Earth were Mathematically round, the Rains would seldom fall where they were wanted.*

The CONTENTS.

- Sect. XXX. *Convictions from thence.*
- Sect. XXXI. *Mountains serve to collect watry Vapors from the Air.*
- Sect. XXXII. *Fountains and Rivers proceed from Mountains.*
- Sect. XXXIII. *The furnishing us with Springs and Rivers, is a principal Use of Mountains.*
- Sect. XXXIV. *Convictions from the foregoing Observations.*
- Sect. XXXV. *Egypt moistened by the Nile without Rain.*
- Sect. XXXVI. *The Fertility of Egypt.*
- Sect. XXXVII. *Convictions from the foregoing Observations.*
- Sect. XXXVIII. *Mountains collect Watry Vapors first by Winds.*
- Sect. XXXIX. *Secondly, Vapors are collected by Coldness of Mountains and upper Regions of the Air.*
- Sect. XL. *Thirdly, Vapors are collected by Shadows, proved Experimentally.*
- Sect. XLI. *Fourthly, Other Shadows give Occasion to the Concourse of Vapors, proved by Experiments.*
- Sect. XLII. *Vapors sufficient to produce Rivers.*
- Sect. XLIII. *The Method of computing the Quantity of Rain Water falling in a certain Time.*
- Sect. XLIV. *The Rain of Paris compared with that of Lisle.*
- Sect. XLV. *Rain-Water alone sufficient for Rivers.*
- Sect. XLVI. *There is more Water in the Air than what descends in Rain.*
- Sect. XLVII. *Exhalations from Canals and Ditches.*
- Sect. XLVIII. *Experiments to shew that Evaporations are likewise produced by Cold.*
- Sect. XLIX. *Objections answer'd.*
- Sect. L. *A Calculation after the rate of a Half-Inch daily Exhalation.*

The C O N T E N T S.

- Sect. LI. *Convictions from the foregoing, and a Word or two about the Air-Salt.*
- Sect. LII. *The Wonders of the Nile.*
- Sect. LIII. *Convictions from the foregoing Observations.*
- Sect. LIV. *The Dispositions or Fitness of Mountains for the aforesaid Purposes; and Convictions from thence.*
- Sect. LV. *Rivers require Place wherein to discharge their Waters.*
- Sect. LVI. *Salt preserves the Sea from Corruption.*
- Sect. LVII. *Of Bays and Gulfs of the Sea for the Reception of Rivers.*
- Sect. LVIII. *The Uses of the Sea.*
- Sect. LIX. *The Force of the Sea in bearing Burdens, and Convictions from thence.*
- Sect. LX. *The same Arguments corroborated.*
- Sect. LXI. *The Fishes of the Sea.*
- Sect. LXII. *The Circulation of Waters preserves the Land from overflowing.*
- Sect. LXIII. *Of the Dykes or Sea-Banks of Holland.*
- Sect. LXIV. *Sand stops the Sea, and proceeds from it.*
- Sect. LXV. *The English Channel preserves Holland.*
- Sect. LXVI. *The Cause of Ebbing and Flowing designedly omitted.*
- Sect. LXVII. *Water bestowed in such great Abundance, and for so many Ages gratis upon Living Creatures.*

CONTEMPLATION XX. Page 545.

Of the E A R T H.

- Sect. I. *Transition to the Earth.*
- Sect. II. *The Earth produces Grass, Corn, &c.*
- Sect. III. *Beasts or Cattle are Kitchens for the Grass.*
- Sect.

The CONTENTS.

- Sect. IV. *Convictions from the foregoing Observations.*
Sect. V. *Different Productions and Powers from the same Earth.*
Sect. VI. *Convictions from the foregoing Observations.*
Sect. VII. *Earth is never consumed, nor becomes entirely barren.*
Sect. VIII. *An Experiment, proving that Air makes the Earth fruitful.*
Sect. IX. *Convictions from thence.*
Sect. X. *The Earth seems to be render'd Loathsome by Filth and Nastiness.*
Sect. XI. *Such Loathsomeness prevented, and Convictions from thence.*
Sect. XII. *The Circulation of almost all things from Earth to Earth, and Convictions from thence.*
Sect. XIII. *Several Texts of Scripture proving the same, and Convictions from the whole.*
Sect. XIV. *An Experiment about distilled Earth.*
Sect. XV. *The Earth produces Instruments applicable to the rendering itself more useful.*
Sect. XVI. *Of Alchymists, and an Explanation of the Texts, Exod. xxxii. 20. Deut. ix. 21. about Gold.*
Sect. XVII. *Gold may be burnt and reduced to Dust.*
Sect. XVIII. *About Precious-Stones.*
Sect. XIX. *About the Loadstone.*
Sect. XX. *When the Virtue of the Loadstone was discover'd.*
Sect. XXI. *The Roundness of the Earth.*
Sect. XXII. *The whole Earth is a flattish Bowl.*
Sect. XXIII. *The Gravity of all Earthly Bodies.*
Sect. XXIV, and XXV. *The Center of the Earth is a Nothing.*
Sect. XXVI. *The Globe of the Earth keeps the same Obliquity.*
Sect. XXVII. *Without such Obliquity of the Earth there would be Reason to apprehend a general Destruction.*

THE CONTENTS.

- Sect. XXVIII. *Convictions from thence.*
Sect. XXIX. *The Earth remains above the Waters notwithstanding its greater Gravity.*
Sect. XXX. *Concerning the Torrid Zone.*
Sect. XXXI. *The Torrid Zone inhabitable by the Means of Mountains.*
Sect. XXXII. *The Inundation of Rivers do likewise render the Torrid Zone Habitable.*
Sect. XXXIII. *Convictions from thence.*
Sect. XXXIV. *Concerning the Temperate Zones.*
Sect. XXXV. *The Advantages of the most Northern Parts.*
Sect. XXXVI. *The Christian Religion is no Art to Politicians.*
Sect. XXXVII. *Atheists differ from the wisest Men.*
Sect. XXXVIII. *Concerning the Frigid Zones.*
Sect. XXXIX. *The Impossibility of approaching the Poles.*
-

CONTEMPLATION XXI. Page 521.

Of FIRE.

- Sect. I. *Transition to Fire.*
Sect. II. *The Inconveniencies that would befall us if there were no such thing as Fire in the World.*
Sect. III. *Convictions from thence.*
Sect. IV. *It is still uncertain what Fire is.*
Sect. V. *The first Notion concerning Fire.*
Sect. VI. *The Second Notion ; Fire seems to be a particular Matter.*
Sect. VII. *The first Reason for the abovesaid Opinion.*
Sect. VIII. *The second Reason, and an Experiment.*
Sect. IX. *The third Reason, and an Experiment.*

Sect.

The C O N T E N T S.

- Sect. X, and XI. *The fourth Reason, and several Experiments.*
- Sect. XII. *The fifth Reason, and several Experiments.*
- Sect. XIII, and XIV. *The sixth Reason, and an Experiment.*
- Sect. XV. *Convictions from the foregoing Observations.*
- Sect. XVI. *The great Abundance and Superfluity of Fire.*
- Sect. XVII. *The Wisdom of him who restrains the Power of Fire.*
- Sect. XVIII. *An Historical Account of Fire in the Bowels of the Earth.*
- Sect. XIX. *Fire in the Air, and an Experiment.*
- Sect. XX. *Convictions from the foregoing Observations.*
- Sect. XXI. *Convictions from restraining the Power of Fire.*
- Sect. XXII. *After what manner the Fire of the Air and Heavens is preserved.*
- Sect. XXIII. *All the Water in the World not sufficient to extinguish this Fire, shewn by several Experiments.*
- Sect. XXIV. *Some Experiments about the Phosphorus.*
- Sect. XXV. *Of a fluid Phosphorus.*
- Sect. XXVI. *The Preparation of a Phosphorus.*
- Sect. XXVII. *Convictions from the foregoing Observations.*

CONTEMPLATION XXII. Page 628.

Of Beasts, Fowls and Fishes.

- Sect. I. *Transition to the Beasts.*
- Sect. II, and III. *Concerning tame and wild Beasts; and the Text in Gen. ix. 2. relating to the same.*

Sect.

The CONTENTS.

Sect. IV. *The Structure of Beasts in general, and Convictions from thence.*

Sect. V. *Of Procreation in general.*

Sect. VI. *Procreation perform'd after various Manners.*

Sect. VII. *Animals of both Sexes.*

Sect. VIII. *Convictions from the foregoing Observations.*

Sect. IX. *Young Ones produced upon the back of a Pipal.*

Sect. X. *The Food of Animals.*

Sect. XI. *The Motion of Animals in general.*

Sect. XII. *The Structure of Birds.*

Sect. XIII. *The hollow Tubes or Bones of a Bird.*

Sect. XIV. *The Cartilages in the Joints; and Convictions from thence.*

Sect. XV. *How are moved in flying.*

Sect. XVI. *The wonderful Structure of the Wings.*

Sect. XVII. *Convictions from the foregoing Observations.*

Sect. XVIII. *Other Reflections upon the Structure of Birds.*

Sect. XIX. *Of the Feet of Water-Fowl.*

Sect. XX. *Of the Tails of Birds.*

Sect. XXI. *The Center of Gravity, and Force of the Muscles of the Wings.*

Sect. XXII. *Convictions from the foregoing Observations.*

Sect. XXIII. *Of the Support of Birds.*

Sect. XXIV. *Transition to the Fishes.*

Sect. XXV. *The Miracle of Fishes living under Water, and Convictions from thence.*

Sect. XXVI, XXVII, XXVIII. *How Fishes Balance themselves in and against the Waters, illustrated by several Experiments.*

Sect. XXIX. *The Effect of Cold and Heat, and of a greater or lesser Column of Water pressing upon Fishes, shewn Experimentally.*

Sect.

THE CONTENTS.

- Sect. XXX. *Convictions from the foregoing Observations.*
- Sect. XXXI. *Fishes swim with their Tails.*
- Sect. XXXII. *The use of their Finns.*
- Sect. XXXIII. *Creatures that live in the Air see confusedly in the Water.*
- Sect. XXXIV. *To prevent this confused Sight, Fishes are endowed with rounder Eyes.*
- Sect. XXXV, and XXXVI. *The Fruitfulness or Number of Fishes.*
- Sect. XXXVII. *The Curse appears from the Production of Fishes.*
- Sect. XXXVIII. *Creeping Creatures not yet thoroughly known.*
- Sect. XXXIX. *Of Insects, Silk-worms, Caterpillers, &c.*
- Sect. XL. *Of the small Animalcula in general.*
- Sect. XLI. *Of the Eyes of a Fly called Rombout, and Convictions from thence.*
- Sect. XLII. *Something of the Beginning of Action in Beasts.*
-

CONTEMPLATION XXIII. Page 685.

OF PLANTS.

- Sect. I. *Transition to the Plants in general.*
- Sect. II. *Without Earth and Water no Plants will spring from their Seeds.*
- Sect. III. *Every Seed has its Seed-Plant.*
- Sect. IV. *The Seed-root and Pluma in a Bean.*
- Sect. V. *Every Plant has two Roots.*
- Sect. VI. *The Cavity in the Bean for the Pluma.*
- Sect. VII. *The Hole in the Skin for the Roots-Sprout.*
- Sect. VIII. *The Nutricious Juice or Sap changes its way in the Seed.*

Sect.

THE CONTENTS.

- Sect. IX. *The Seed-Leaves and their Use.*
Sect. X. *Of the Expansion or Unfolding the Seed-Plant, with an Experiment of Mr. Dodart thereupon.*
Sect. XI. *Whether the Seed-Plants contain the following Ones.*
Sect. XII. *Transition to Roots, and Trunks of Plants.*
Sect. XIII. *The Structure of the Root, and its Parts.*
Sect. XIV. *This Structure represented in the Pepper-Root.*
Sect. XV. *The Structure of the Trunk in an Ash-Tree.*
Sect. XVI. *The Trunk grows upward and the Root downwards.*
Sect. XVII, XVIII, XIX. *Three Experiments made upon Beans, Acorns, and other Plants.*
Sect. XX. *Convictions from the foregoing Observations.*
Sect. XXI. *The Knots and Buttons of Plants, and Convictions from thence.*
Sect. XXII. *The Structure of Leaves, and their Usefulness.*
Sect. XXIII, XXIV, XXV. *Several Experiments to shew the Perspiration of Leaves.*
Sect. XXVI, XXVII. *The Structure of Flowers, with their Supporters and without.*
Sect. XXVIII. *Some Singularities about Flowers.*
Sect. XXIX. *The little Threads of Plants, and Convictions from thence.*
Sect. XXX. *Of the Curse of the Earth.*
Sect. XXXI, XXXII. *Plants don't yield as much as they are able, and a Proof thereof shewn in Trees.*
Sect. XXXIII. *Convictions from the foregoing Observations.*
Sect. XXXIV. *Of Sea-Plants.*
Sect. XXXV. *Convictions from all that has been said above.*





T H E

Religious Philosopher :

Or, the Right Use of the
Contemplation of the Works of
the CREATOR, &c.

VOLUME II.

CONTEMPLATION XVII.
Of the AIR.

SECT. I. *Transition to the Contemplation of the
World.*

HITHERTO we have been employ'd in
Contemplating what we our selves are,
and with how much Wisdom and
Power, and (what lays under us higher
Obligations) with how much Goodness
our most gracious Creator has thus wonderfully
Formed us, and daily and hourly Supported us. If
now we proceed, and cast our Eyes upon all that

is round about us, we shall again discover a whole World full of innumerable Bodies, innumerable Motions, innumerable Phænomena or Appearances, innumerable Operations and Effects of an inexpressible Number of Things, in such a manner, that the indefatigable Diligence of the most laborious and experienced Enquirers has only hitherto been able to bring 'em so far as to be forced to confess, that, in relation to the Universe, all what they know to this Time, can only be accounted a very small Part of what is to be known.

SECT. II. *First of the Air.*

TO the end that we may not be brought into Confusion whilst we are Contemplating such an unconceivable Number of Things, but observe some kind of Order, we will begin with those that are absolutely useful and necessary to the Support and Well-being of Men ; therefore we shall treat of AIR, which is the principal of them all ; and first, of some Properties thereof, and then of what Advantage and Service it is to Men, Beasts, Plants, and other Things ; all which we shall briefly shew in some few Cases.

SECT. III. *The Gravity and Elastick Faculty of the Air.*

THE Diligence, or rather the good Fortune, of the Philosophers of the last Age, has brought to light two remarkable Discoveries, and which were entirely a Secret to all the Ancients, touching the Constitution of the Air ; namely its Gravity or Weight, and its Springiness, called in Latin by the Modern Naturalists, *Vis Elastica*.

SECT. IV. *An Experiment concerning the Gravity of the Air.*

FOR some thousand Years the Air was esteem'd to be a Body so light, that it would never descend like other Bodies, till the Invention of *Barometers* gave the first hint to Mankind, that the Air might likewise be a heavy Body.

And how greatly the Experiment of these Weather-Glasses has contributed to the chief Proofs of the Gravity of the Air, may be seen by the Suspension of the Quicksilver in those Tubes in many Cases, which is to be ascrib'd, first to its Elastic Faculty, and afterwards to its Gravity, which causes the said Faculty to exert itself; as will appear by what follows.

Wherefore, in order to prove directly the Gravity and Weight of the Air, this Method seems to afford the strongest Proof, or at least the clearest and simplest: Take a Glass full of Air, and weigh it in a nice and exact pair of Scales; then draw out the Air as far as possible with an Air-Pump, and weigh it again; at which time you will find that it is sensibly heavier before the Air is exhausted than afterwards. The Glass-Bubbles, which are commonly sold with the great kind of Air-Pumps, and their *Apparatus* are very proper for such an Experiment, and bigger Glasses are yet more so.

I find in my Notes, that a Bubble had lost with its Air sixty two Grains of its Weight, which is more than sufficient to convince us of the Gravity of the Air. According as we make use of bigger or smaller Bubbles, this Difference will appear greater or less.

SECT. V. and VI. *The Air's Elastick Faculty, proved Experimentally.*

THE Second Property, for the Knowledge of which we are beholden to the Discoveries of later Years, is the *Elastick Power* or *Springiness* of the Air; whereby its Parts, like Steel Springs that are bent with Force, do continually endeavour to expand themselves; and so by their Separation from each other, to occupy a larger Space, protruding and pressing on every Side all that makes any Resistance to them.

To prove the same, many Experiments have been made by the Famous *Boyle* and others. The common Method of shewing it is by a little Bladder E (*Tab. XIII. Fig. 1.*) which being blown, acquires a certain Magnitude; for instance, that of a large Goose Egg; out of this you must squeeze almost all the Air, insomuch that it may be pressed close together, leaving only a very small Quantity at the Bottom of it; then tie it close at the Mouth, and hang it by its String to the little Hook D, in the Glass Bell A B C, such as is used with Air-Pumps; then exhaust the Air out of the Bell at F, whereby that little Quantity that remained in the Bladder E, will be discharged from the Pressure which the Air in F, round about the Bladder, does otherwise make upon it, and by which Pressure that in the Bladder E was hinder'd from expanding itself: Whereupon the Elastick Power of its Parts finding no Resistance, exerts itself presently, in dilating the Bladder in the very same manner, as if one should blow very strongly into it thro' a Pipe.

And for a further Proof of this Elastick Power of the Air, several other Experiments, hereafter quoted in the proper Places, may be serviceable.

SECT.

SECT. VII. *The Pressure of the Air.*

NOW that Operation or Effect which the Air has upon other Bodies, by this its Weight joined to the Expanding or Elastick Force of its Parts, is what the Moderns call the Pressure of the Air: The surprizing Strength of which is incredible to many, and the Properties in its Uses no other than wonderful.

SECT. VIII. *The Mistakes of some Atheists.*

NOW before we proceed any farther, let those stand forth, who that they may continue undisturbed in their unhappy Notions (namely, that there is not much Wisdom nor Power requisite towards the Direction of many things that are round about 'em) think that they have discover'd a great Proof; forasmuch as it seems to them, that many of those things are entirely at Rest, or at least are not moved but very slowly and insensibly. Now when one supposes things to be without Motion, there does not seem much Wisdom nor Power necessary to continue them in the State in which they are; because a slow and languid Motion is known not to want so much Force and Direction to do no Mischief, as that Motion which has more Velocity and Strength in it: And if this last be allowed, the first carries a great deal of Probability with it, at least in the Minds of ignorant Persons: For several People sitting in a Chamber, for instance, are not sensible of any Force upon them from Powers operating externally; the Glass of the Windows that is known to be so brittle remains in the same Condition; the Tapistry or Hangings

of the Room immoveable ; not a Hair of their Head stirs ; in short, every thing seems to them plainly enough to be in perfect Rest. Let 'em go abroad, and unless the Air be put into Motion by Winds or Storms, they meet with no violent Opposition, but every thing seems still and calm to them ; from whence they conclude that at such times they are Safe and Secure enough, and stand in need of no greater Power than they themselves are able to furnish for their own Defence.

This Mistake does oftentimes render the unhappy Atheists very easie for a while, and makes them flatter themselves, that there is nothing about them which they need to fear. But in order to excite different Thoughts in them, and to make them apprehend Matters as they really are ; let them go on and Contemplate with us those great and terrible Powers, which, even at the very time that they think themselves to be in the surest Calm and Stillness, move continually round about them, and they continually live in the midst of 'em ; which Powers, if they were not most wonderfully restrained by an *Equilibrium* or Balance, (and so hinder'd from hurting us, and thereby only render'd insensible) would be able, as soon as ever that *Equilibrium* ceased to operate, in an instant of Time, to crush us into Atoms.

SECT. IX. *A Description of the Barometers ; and an Experiment of the Pressure, and of the Weight of the Air thereby.*

Now to the end that this may not appear to any one more marvellous than true ; take a Glass Tube A O (*Tab. XIII. Fig. 2.*) of about three Foot in length, and of the bigness of a Goose or Swans Quill, closed at A and open at O, let it be filled with Quicksilver ; then stopping the Orifice

Orifice O, with your Finger, turn it down into another Vessel of Quicksilver, as described here in the Glass B O D; then drawing your Finger away, the Quicksilver that is in the Tube will have an opportunity of sinking down, some of it running to the other that is in the Glass. But it is well known to all that have taken any Pains to enquire into the Modern Philosophy, that the said Quicksilver that is in the Tube will stop about F, at the height FI of 28, 29, 30, or 31 Inches above the uppermost Superficies B D of the Quicksilver that is in the Glass Vessel. Now that this happens, because the Air does equally press upon this Superficies B D that is out of the Tube, as the Quicksilver within does upon that Part C I, which is directly under the Tube, will appear from the following Reasons.

I. Because when the Pressure of the Air upon the Quicksilver B D out of the Tube, is greater or less, that within the Tube does either rise or fall, as is obvious in all the *Barometers* or Weather-Glasses which are only made after this manner.

II. This may be likewise deduced from thence, that in case we pour Water, Lye, or any other heavy Liquor to the Height W K, upon the Quicksilver B D, and so augment the Pressure with that additional Weight, the Quicksilver at F will be proportionably higher; and again lower, if we draw the Water off by a Pipe or Crane, and thereby lessen the Pressure upon B D.

III. The same is very plain, if we cover the whole, with a long Glass Bell, H G L, on the Air-Pump, and by exhausting the Air in P, or in the said Bell, from thence into the empty Pump remove the Pressure which this Air made upon the Quicksilver B D; for then we shall see that the other in the Tube between I and F, will descend to C I, or about as low as that which is in the Glass out

of the Tube, and rise again to the same Height F, when we let in the Air again to the Bell, whereby the Pressure upon the Superficies B D may be increased.

Hence then it is plain, that while the Quicksilver stands thus still in the *Barometer*, and in the Glass Vessel in the open Air, every like part of the Horizontal Superficies of the Quicksilver Y X (which may be supposed to pass through under the Orifice of the Tube O M) suffers a like Pressure; because otherwise the Quicksilver would not remain at rest, but the Parts of it that were more strongly pressed would recede downwards, and the Parts that were least pressed would be compelled to ascend; which is sufficiently known from the Principles of *Hydrostaticks*; for which reason then, if one supposes the Part N Q, to be equal to O M, both of 'em will undergo an equal Pressure; for the Parts of the Quicksilver R N Q S, and C O M I, being of equal Height, are likewise of equal Weight; and since they are at rest, they must have the same perpendicular Pressure; the Part R S, which is in the open Air, will be as much pressed by the perpendicular Column of Air T R S V, as the Part C I, which is in the Tube, by the impending Column of Quicksilver Z F C L. And to conclude; each part of every thing that has Air impending over it, suffers as great a Pressure as if there were a Column of Quicksilver of 28, 29, 30, or 31 Inches upon it, according to the Height in which it is found at that time in the Barometer.

Now, according to our Experiments, as well as those of others, Quicksilver is about 14 times as heavy as the like quantity of Water; and so the Air presses as strongly upon every thing over which it is impending, as if there were fourteen times
it

twenty eight Inches, or reducing the same to Feet, as if there were $32\frac{1}{2}$ Feet of Water (taking it at the very lowest) lying upon it.

SECT. X. *A Barometer of Water and Lye, and some Experiments.*

Now that we may not be here mistaken in the Deduction of Consequences, which often happens in Physical Enquiries (forasmuch as when we think to have deduced by good Arguments a second Phænomenon from a once made Experiment, we do not always find the matter of Fact to agree with our Thoughts; since in the second Trial, other Causes may likewise intervene and co-operate, which we did not think of in the Deduction, as it happens to those that exercise themselves in such Enquiries, more frequently than they could wish;) I therefore took a Tin Tube of 36 Foot in Length, but found tho' it had been made with great Exactness, that it was not compleatly Wind-tight; wherefore there was another Tube of Glass of about the samelength prepared in order to make it a Barometer of Water: This was fasten'd to a piece of Wood, and then tyed to the Wing of a Wind-mill, and so let down perpendicularly, its lower end being first stopt with a Cork and Bladder; after which some Body filled it full of Water from above, stopping at every turn till the Air got above the Water; being full, it was after the same manner carefully stopt with a Cork and Bladder; then the lower Orifice of the Tube that stood in the Water being open'd, the Water in the Tube immediately descended, but stood still at the Height of about 33 Feet, as the Quicksilver does in a Barometer; till the upper Orifice being likewise unstopt, and the Pressure of the external Air thereby admitted,

the whole Mass of Water that was in the Tube suddenly subsided into the Cistern. Thus this Experiment shews the Agreement between the Matter of Fact, and the Consequences that we have before deduced touching the proportionable Gravity of Water and Quicksilver; namely, that Air presses upon all Bodies with the same force as Water would, if it were impending over them about 33 Foot.

If any one should have a Mind to try the same Experiment, but had not the opportunity of procuring from proper Glass-Blowers such a Tube of 36 Foot in Length, he may, as we do, make use of the broken Necks of Bolt Heads or little Chymical Phiols that People buy at *Amsterdam* for a Stiver a piece; these being thrust into one another, may be joined with the *Emplastrum de Minio*, or Red-Lead, mixed with Oyl of Olives, and boil'd up to the Consistency of a Salve; and putting a wet Bladder over it, bind it about with small Packthread: This will make a Tube as perfectly Wind-tight for a while, and as good for the Purpose, as if it had been one whole piece.

Another thing which must not be here past by, is that the subsiding of the Water with an infinite Number of little Bladders appeared ascending thro' the Water, which did not proceed from the external Air, but from that which was in the Water; the Cause of which was, that by the subsiding of the Water there was an empty space left above in the Tube, and consequently the Pressure upon the Water was removed; whereupon the Air that was in the Water, expanding itself, ascended just after the same manner as we see it happen in Water, under the Bell of the Air-Pump, when the Air that pressed upon it at first is exhausted.

They

They that desire to be entirely satisfied of what we here mention, may fill the Tube of the Barometer (*Tab. XIII. Fig. 2.*) A O M, with Water instead of Quicksilver, and place it in the Glass Vessel that is likewise filled with Water up to B D; then pumping the Air out of the Bell H G L, they will see the Water subside from A to F, and lower; but in the mean while numberless little Bubbles ascending in the Water for the Reasons before-mention'd; and that those Bubbles are really Air, and not the Water itself, may appear, *First*, By letting the Air into the Bell again, because that the said Air remaining above at A F, will hinder the Water from being prest by the Air *p*, and rising higher in the Tube than F. *Secondly*, Because if you let out the Air that is in the Bell at P, any farther, the Air at A F expanding itself, will press the Water a great way beneath C I, or B D, where descending only by its own Weight it would have stopt by itself. *Thirdly*, For a farther Proof of the aforesaid, you may see by taking away the Bell H G L, and holding a Coal of Fire near the Air at A F, that the Water being rarified by the heat of the Coal, will be pressed down to Z F; which as soon as the Air at A F becomes cold, will ascend again.

I find these Particulars among my Notes upon this Experiment, to prove that it is not possible to make a lasting Barometer of Water, which would otherwise have a great many Advantages over those of Quicksilver. If instead of Water one should take Lye (which tho' it had stood six Years in the open Air, had never admitted any Air into it, at least as far as could be discover'd by the help of an Air-Pump) it might perhaps furnish us a useful Barometer, and in my Opinion, even better than one of Water, out of which the Air
has

has been driven by Boiling, because after a while the Air mingles itself again with the Water.

I hope this Account will not be unacceptable to such as do not understand the true Properties of the Barometer, tho' it be now very common; the rather, because what we have said above (namely, that the Force with which the Air presses upon all things, is equal to that of a Column of Water of about 33 Foot in Heighth) is shewn in all its Circumstances; and so every one that represents the thing to himself, may consider the terrible Powers which, tho' he feels nothing of 'em, are continually exerting themselves upon, and round about him.

SECT. XI. *The Dreadful Pressure of the Air upon a Man.*

Now to shew the incredible Greatness of that Force which the Air exercises upon our Bodies, let us for once suppose it being too laborious and unnecessary also to describe the same with the utmost Exactness) that a Man of 6 Foot in Heighth, is one Foot in Breadth from Top to Bottom, the broader and narrower Parts being reckon'd together; so that the Superficies of his Body, both before and behind, may comprise 6 Foot each, the roundness of the Sides being counted in, if this Computation should seem too large.

Now according to the foregoing, every Foot in Breadth supports as much Weight as if there were a Column of Water of 30 Foot at least upon it; we put 30 instead of 33 Feet here, because the Air has a different Weight at different Times, and the very smallest of it will be a sufficient Proof of our Hypothesis.

And

And every Cubical Foot of Water weighs about 63 Pounds, as we have found it upon Trial, tho' others make it a little heavier, which may proceed from several Causes, such as the difference of Waters and Seasons, and of the mixture of more or less Air therein ; but this is not material, for the smallest Weight is here the strongest Proof.

This then being supposed, altho' this Pressure upon our Body is most sidewise, and (excepting that upon the Head) is rather a lateral than perpendicular Pressure ; yet it is well known to those that understand *Hydrostaticks*, that by reason of the height of the Air, and the smallness of a Foot with respect thereto, there is little difference between the lateral and perpendicular Pressure ; and he that is no Mathematician may likewise experience the same ; because, whether he stands up an end, or whether he lies all along upon the Ground (at which time the Air will press perpendicularly upon every part of his Body) he does not perceive the least Difference. From whence it then follows, that upon every Superficies of one Foot of our Body, there always lies a Weight of 30 times 63, that is, 1890 Pounds ; and accordingly, upon 6 Foot, which we have supposed to be the Breadth of the Body 6 times 1890, that is, 11340 Pounds, with which Weight our Body is pressed only before, or behind ; so that if you take the whole Force of the Pressure, which is equally born on both sides of the Body, the whole Weight will amount to 22680 Pounds. Now to avoid any mistake, and for the roundness of Number, we will suppose it to be no more than 20,000 Pounds, which is certainly not too much.

SECT. XII. *Convictions from the foregoing Observations.*

Now could any Body have imagined, if this irrefragable Truth had not been demonstrated by the plainest Experiments, that when he thought he was free and felt nothing, he should be loaded upon every part of his Body before and behind with no less a Weight than that of 20,000 Pounds; and that nothing could have saved him from being crushed to pieces by so terrible a Force, than that exact Balance of Power against it; whereby the one operates just as much in favour of us, as the other would do to our Prejudice.

Now that this most astonishing Force would be more than sufficient to crush our Body to pieces, can be doubted by no Body; forasmuch as if the Pressure of 10,000 Pound Weight upon one side should cease to resist or balance the like Weight on the other, our Body would feel the same, just as if a Weight of 10,000 Pound did press upon the forepart of it, not only slowly and gradually, which yet would be enough to deprive us of Life, but as much as if the like Weight of so many Thousand Pounds were suddenly cast against our Body: For the Elastick Power of the Air, if the Balance thereof be taken away, exerts its Pressure with a more terrible Velocity than can be imagined. Now since every one of us is bound to acknowledge herein a Power preserving him every Minute from utter Destruction; and that the same Power operates according to the Rules of a wonderful Wisdom; can we do otherwise than ascribe all this to an infinitely Wise Director? And if it cannot be deduced from ignorant Causes, let the Atheists consider with himself what he has to expect for such Blasphemous Negations of so wise and mighty a Being.

SECT.

SECT. XIII. and XIV. *Experiments shewing the Pressure of the Air.*

Now as strange as all this may appear to any Body, yet all they who are conversant with Air-Pumps, know that it is true. For if on the Top a round Brass Vessel (*Tab. XIII. Fig. 3.*) which is open at C D, you fix a flat Glass A B, which is adapted to the upper Orifice thereof; and (to prevent the entrance of the least External Air N, and mixture with that of K in the little Vessel) thro' the Passage which is between the Glass A B, and the Circumference of the Vessel, it be stopp'd with a mixture of Sheeps Suet and Wax, and so set down together upon the Copper Plate H I, of the Air-Pump and its Leather; then the Glass A B (like all others that are in the Air) will remain wholly unmoved between the equal Pressure of the opposite Air at N and K, as is sufficiently known.

Now that this only happens on account of the exact Balance of both those Columns of Air, by means of which the Air at K presses the Glass upwards, with just as much Force as the same is prest downwards by that at N, may appear from hence; forasmuch as when the Force of the Air at K is never so little diminished by letting out some of it thro' the Pump, one shall see that the Column E A B F, of the external Air N, pressing upon the other side of the Glass, will not only burst it, but will break it all to pieces with a noise like the discharge of a Gun; which to perform in the like manner would require a very great Strength and Swiftnefs in the blow of a Hammer.

The said Force of the Air appears likewise by exhausting as far as one can the Air out of a Globe of Glass A B (*Tab. XIII. Fig. 4.*) and afterwards, having turned the Cock E, by taking the same off
and

and placing it in a Vessel of Water L F G M, with its Orifice D downwards. Then turning the Cock E back again, whilst it is under the Water, so that the said Water may enter into the Globe by the part D B; whereupon immediately as soon as the Cock E is open'd, the Air at H and K, gravitating or pressing upon the Water L M, which is on the outside of the Tube D B, exerts its Force, causing the Water to spring thro' the Tube into the empty Globe with as much Violence and Swiftneſs as a Fountain, so that it will very much surprise those that have never seen the like.

Now that the Cause thereof is, that by exhausting the Air out of the Globe A B, the Opposition or Resistance is likewise taken away; which otherwise, when the Globe is full of Air, does with equal Force withstand the Water driven up thro' the Tube D B, by the Pressure of the external Air at H and K, is plain from hence; because we know that upon admitting the Air again into the Globe, and putting every thing in *Statu quo*, there will not be the least Motion discover'd in the Water; which being pressed upwards and downwards with equal Force in the Tube B D, between the two Powers of the Air within and without the Globe, reciprocally acting upon each other, does consequently remain quiet, and as far as it appears, without any sensible Disturbance.

SECT. XV. *Convictions from the foregoing Observations.*

Now I submit it to any Body, who from what we have here said, has attained to a true Idea and Conception of these dreadful Powers of the Air; whether instead of believing, that all things in which he can discover no Motion round about him, do remain at Rest; whether, I say, he

is not now convinced that he is every moment of his Life encompass'd with such a Force as acts upon him and every thing besides; and of which, if the Wisdom of the great Director did not hinder it by an *Equilibrium*, from exerting all its Strength upon him, the half only would suffice to crush him and every thing else breathing, to pieces; and consequently, whether he can imagine, that it is by mere Chance only, and without any Wisdom, that while he walks in the midst of it, he is preserv'd from the fatal Effects thereof; the rather if he does at all reflect upon the following wonderful manner of such Preservation. As *first*, that a very small Part of the Air, and which is hardly worth Naming, should be capable of making a Stand, and of balancing an unspeakable greater Quantity thereof; and hinder it from crushing most of the things that are under it. *Secondly*, that besides such a Resistance, the aforesaid small part of the Air, does equally operate and gravitate with all the rest of the Air extended even to the Clouds and higher. Now as the first hinders every thing from being destroyed; the second is no less useful to Men, tho' they are capable of using but a very little thereof.

SECT. XVI. *A little Air resists a greater quantity.*

One may see an instance of the first, in *Tab. XIII. Fig. 3.* where a Glass A B, impervious to the Air, is placed upon a little Vessel A B C D; which standing upon the Copper-Plate, and its moisten'd Leather, H I, is thereby closed at Bottom, as it may be after another manner, if People will, so that the little Air at K, remaining inclosed therein, makes so equal and so compleat a Resistance against the Air E A B F (which otherwise, as we have shewn above, breaks the Glass, and being extended from the Top of the Clouds down to the Earth,

does a thousand Times surpasss the Air at K, both in Quantity and Gravity) that the Glass A B, tho' never so thin and brittle, is not in the least hurt thereby.

SECT. XVII. *A little Air gravitates as strongly as a great deal.*

THE *Second*, by which we see that a small quantity of Air (besides the Resistance abovemention'd) does likewise gravitate and press equally with the whole external Air, may be first proved by *Tab. XIII. Fig. 2.* where the Quicksilver in the Barometer A I, with its little Glass, B X, standing in the open Air, is thereby raised and suspended to the Heighth F I. Now if you cover the whole with the Glass Bell H G L, so that no Air, besides that which is in the Bell can act upon the Quick-Silver at B D; yet you will see that that which is in the Tube, will preserve the said Heighth of F I. So that it is here proved unanswerably that the Air in the Bell, how little soever it be, gravitates as strongly, yea, even more upon the Quicksilver B D, than the whole external Air had done before.

But in *Tab. XIII. Fig. 5.* you may have an ocular Demonstration of it, if you place a long Tube F O (like that of a Barometer, but open at both ends) in a little Glass Vessel G K P Q thrusting it thro' the covering of the said Glass Vessel G K at I, and closing it round about; into this Vessel you must pour thro' the little hole at N, (which was stopt before with a Screw) some Quicksilver till it rise up to B D, a good deal higher than the end of the Tube O, whilst the rest of the Vessel B D G K, has nothing but Air in it. Then stopping again the little hole at N, with the Screw, set the whole Apparatus under the Bell

HSL,

HSL ; and exhausting the Air V V, you will see that the little included Air at G B D K, will lose its Resistance, and Pressing upon B D, by its rarifying and expansive Faculty, will force the Quicksilver in the Tube to ascend to the Height of F ; which was about the same with that at which the Quicksilver remained standing in a Barometer, when suspended by the Pressure of the whole Air.

SECT. XVIII. *The Difference between the Gravity and Elasticity of the Air.*

NOW the first (that is to say, the Resistance which a small Quantity of the Air makes against a greater) is common to all other Liquids, according to the wonderful Laws of *Hydrostaticks*, to which the weight of all Fluid Matters submits itself in its Operations. Accordingly we see, that all Liquors press'd upon, do either press reciprocally, if they be Elastical, or otherwise resist like solid Bodies, as may be experienced in a closed Syringe or Air Pump, in which there is either Water or Air ; this last effect however, ought to be rather ascribed, as we think, to the Airs Elastic Faculty, than the weight thereof, which appears from hence, that the weight of the included Air G B D K, does hardly bear any Proportion to that of the Quicksilver in the Tube F I ; and again, because if we should fill the space G B D K, where the Air is, with a heavier Matter, or with Quicksilver itself, the Quicksilver in the Tube (tho' the Air were exhausted out of the Bell) would not rise higher than I.

SECT. XIX. *How the Elastick Power of the Air works by the Gravity thereof.*

NOW in order to understand in some manner, how the weight of the Air and the Springiness thereof, do produce these their Operations with one another, we must represent to ourselves, that in *Tab. XIII. Fig. 6.* there is a Column of Air, A H, consisting from Top to Bottom of a great Number of Air Particles, such as A, B, C, D, E, F, G, P, &c. each of which have a certain Weight, whereby they gravitate upon those that are under them.

We must likewise suppose, that in each of them (of what Figure soever they be) there is an inherent Elastical Power; by which, like the Steel Springs of Watches, &c. being bent together, they endeavour to expand themselves again with the same force wherewith they were bent.

From hence it follows, that the lowermost Parts of the Air, G and P, &c. bearing the Weight of all those that are above 'em, must be more bent than those that are higher and bear a lesser Burden, as A B C; for which reason the undermost, P G, endeavouring more forcibly to reinstate themselves, will press the Body, I K, that supports them, with more violence, as those that stand above the Body N O, do the same.

And so far the Point H bears no more than the Weight of all the Air-Particles, A B C D E F G P, &c. which stand upon one another without any remarkable Alteration of the Elastick Power.

But if we proceed further, and place another solid Body between these Air-Particles, thereby cutting off those that are at P and G, from the aforesaid Column, and likewise encompass the place L I K M, by solid Bodies, in such manner, that the Air-Particles, P and G, are entirely separated

parated from the others. If now (as in Water which has little or no Elasticity) the Parts P and G, did press by their Weight only upon the Body I K at H; the said Body I K, would be so much less pressed than before, that the Body L M was placed above G; forasmuch as I K does now only bear the Weight of P and G; whereas it had born before the weight of all the Parts of the Air, of which the whole Column A P consisted.

But supposing on the contrary, that the Parts A, B, C, D, E, F, G, P, had all, like the Air, an Elastick Faculty, and should again endeavour to expand themselves in Proportion to the Pressure of those above them; the Body I K, will then be pressed as much by these two Parts P and G, as it was before by the whole Column of Air from A to P; for since the Parts P and G, that were cut off, are contained in the same Inflection, by the Resistance of the solid Body L M, which they had acquired by the weight of the impending Parts A, B, C, D, E, F; their Expansive Faculty, and consequently the Gravitation or Pressure which they make upon the Body I K at H, will remain equally great.

And thus we see, that the weight of the Air-Particles, bearing upon one another from A to P, do press the lowermost P G; and bending the same, do encrease their Elastick Force; so that how little soever they might have been, whilst by the Resistance of a solid Body I L M K, they were hinder'd from expanding themselves farther, these few Parts P G, that are cut off and excluded from the rest, do so powerfully press the Body I K, upon which they act, as if the whole Column of Air A P remained over them.

Now, that this last obtains in the separated Parts of the Air has been lately shewn in §. 17. from the Effects of the included Air in the Place GBDK.

SECT. XX. *The Air that bears most Weight is most compressed.*

WHAT we have just now said, namely, that the undermost Parts of the Air, P and G, being pressed by a greater weight of those that are above them, will be more squeez'd together than those of D and E, which have the shorter Column of Air, A C, over them, and consequently a lesser Weight; may be proved by the following easie Experiment, among others: Take the Tube of a Barometer (*Tab. XIV. Fig. 1.*) let it be open at I, and shut at F; fill it with Quicksilver so far as to leave a little Air at the Top of it; then stop the Orifice I, with the Finger H, and turn it suddenly upside down, so that the Finger which was before at the Top, may now be at the Bottom. This being done, you will see that the Air that remained in the Tube, and which, by the inverting thereof, does now bear the Pressure of the whole Column of Quicksilver, will be immediately contracted into a much narrower space than it was at I; and that as it ascends thro' the Quicksilver from I to F, it will continually possess larger Spaces, because the impending Quicksilver does continually lose of its Height above it; and therefore the higher these Air-Bubbles come, the less Weight they feel; and this is the reason why they appear to us larger at A than at I, at B than at A, at C than at B, and so on, till they have got up as high as F, where being no longer pressed, they are expanded to the utmost Bigness.

We may likewise see the same Appearances, but with less difference of Size, if we fill the Tube with

TAB. XIII

NB. Thro' a mistake of the Engraver the Tables following this, are false Number'd, that marked XIII should be XIV, and so of the rest.

Fig. 2

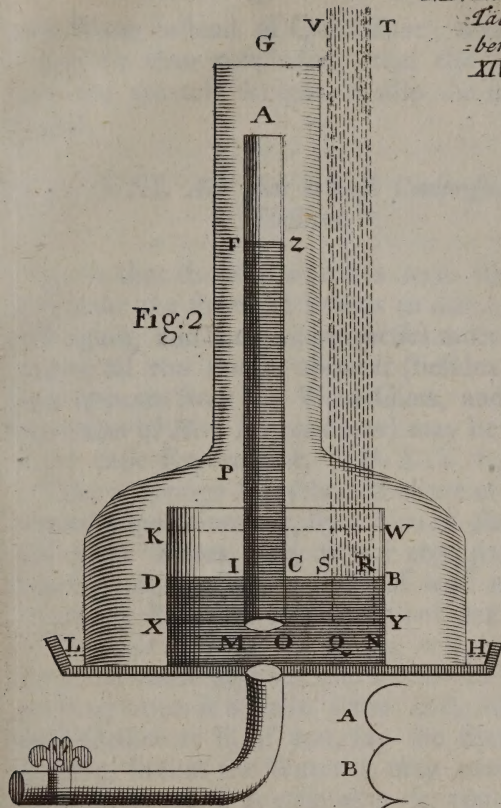


Fig 3

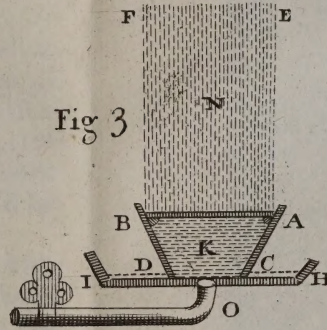


Fig. 1

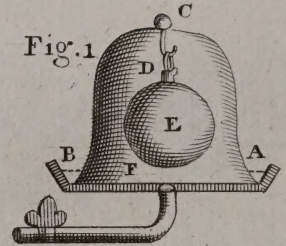


Fig. 5

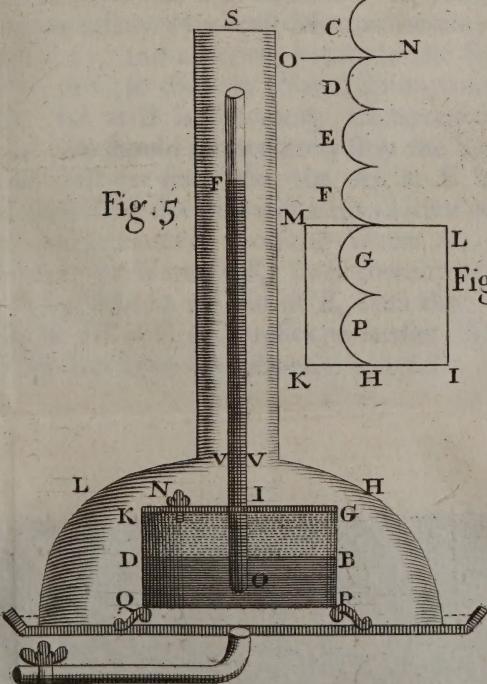
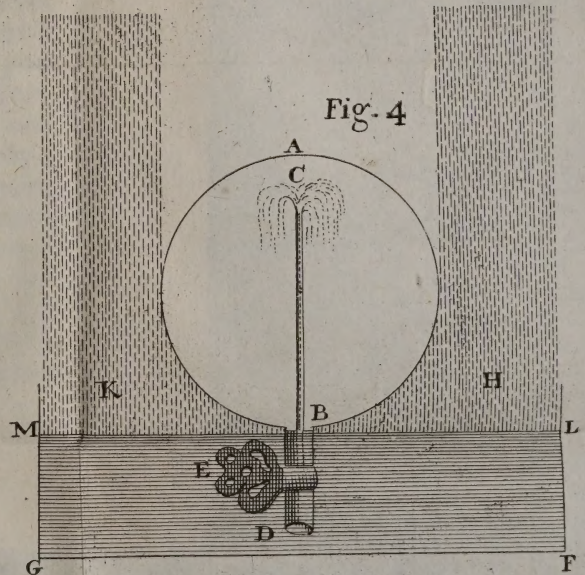
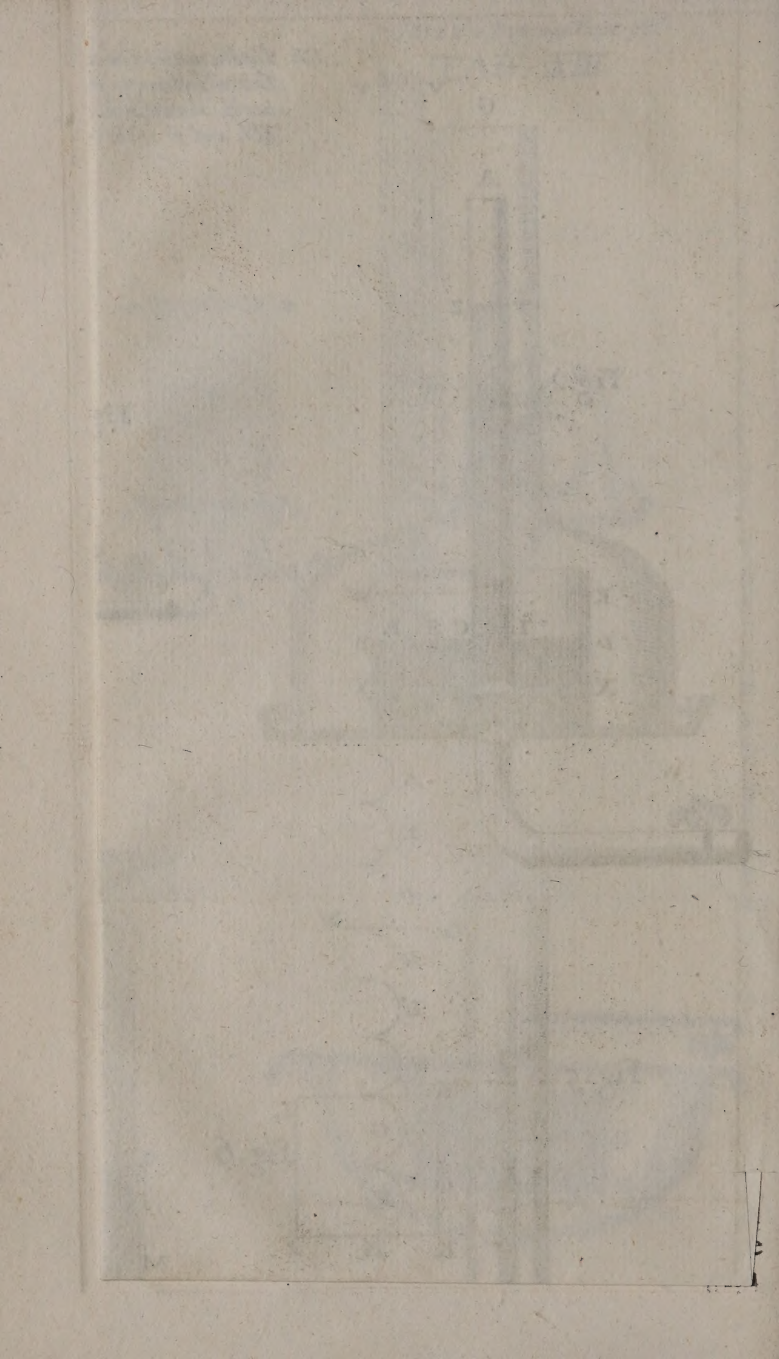


Fig. 6

Fig. 4





with Water instead of Quicksilver; from whence it may be then concluded, that the Air which bears the greatest Weight, is also the most Compressed.

SECT. XXI. *Air that is most Compressed, is most Elastic.*

Now that the Air which is most Compressed, does make the strongest Efforts to dilate or expand itself again, and accordingly presses more powerfully upon all the Bodies about it (besides that, the same appears from the Wind-Guns, and the little Fountains of *Hero Alexandrinus*) may be prov'd by a very easie Experiment, (*Tab. XIV. Fig. 2.*)

Take a Syringe S D (those that are used in Anatomical Operations are, by reason of the Narrowness of the Tubes, very fit for this purpose) and drawing out the Sucker S C half way as far as C, so that the Part A B remains full of Air; put the end or nose of it D, in Water, which will enter into it by drawing back the Sucker to F G; then screwing upon it a little Tube D E, which has a small Orifice at E, if you lay the Syringe Horizontally, so that the Water A may cover the hole D, and the Air B remain over it, you will not be able to discover the least Motion therein; but if you suddenly, and at once, protrude the Sucker from F G, to C, so that the Water Springs out at E, and the Air at B is the more Compressed thereby; tho' you should immediately stop the Sucker again, you will yet find, that the Air at B being more Compressed, does likewise expand itself with greater Force, and presses upon the Water A; so that the Stream of Water E K, does thereby continue for a long time to run out at E, even tho' the Sucker do lie still at C, and presses no farther; from whence what has been said above is proved.

SECT. XXII. *Convictions from the foregoing Observations.*

NOW, if any would Contemplate the aforementioned Laws, and how the formidable Power of the Air is so wonderfully balanced by so small a part of the same, Can he still imagine, that all of it is thus produced by Chance, and without any Design or Wisdom of the Maker?

Without such a Law, and in case that the little Air which is in a Chamber, could not sufficiently balance the vast Ocean of the external Air, how could it otherwise be, but that all our Glass Windows, like the Glass Vessel mention'd in §. 13. should be immediately ground to Powder? Forasmuch as according to the preceeding Calculation §. 11. upon every square Foot thereof there is a continual Pressure of above 1800 Pounds Weight. Without this Law, how could an Army-Tent, a Peasant's House, or a Shepherd's Cottage, yea, even the most stately Edifices, remain standing? Since, if they be taken in their Largeness and Circumference, as an Apartment, which being but ten Foot in Length, and of the same Breadth and Height like a Dye, the four standing Sides, and the Ceiling being each 100 Foot Broad, and each pressed upon with 189000 Pounds Weight, and consequently the whole Apartment would be pressed with five times as much Weight upon all its five Sides, upon which the Air is impending, that is to say, with a Weight of 945000 Pounds. Whereas in the space of 1000 Foot, which the Circumference thereof contains, the whole Body of Air, that resists such an External Pressure, would not gravitate more than 63 Pounds; supposing, with many Enquirers, that a square Foot of Water weighs 63 Pound, and is a thousand Times heavier than a
like

like Foot of Air. Without this Law, how is it conceivable that we, who are continually pressed with a weight of above 20000 Pounds round about us, should not have been long since crushed to Pieces, since the third Part thereof is able to do it? And in case our Breast, by the Roundness of its Ribs and Cartilages, might make some Resistance; How comes it, that our Belly and Loyns are not pressed flat and close together by such a Force; were it not that they did contain some little Air with its Expansive Faculty, which, tho' so very small, is yet able to Balance so terrible a Pressure? 'Tis by such included Air, that we see those Creatures, who are put into a Glass Vessel from which the Air is exhausted by the Pump, swell and grow bigger as soon as the said Air within them expands itself, for want of an External Resistance and Balance. This Experiment I find in my Notes to have been made upon a *Mouse*, a *Kitten*, and other such little Creatures.

Now can any one imagine, that so far as without this wonderful Balance (by which a small parcel of Air is able to make head against a mighty Column, extending itself up to the Clouds and higher) no House would be Habitable, no Creature could remain alive, but every thing in the World would be broken and crushed to Pieces) I say, can any one imagine, that it is by Chance, and without any Design of the Creator, that there is such an amazing Balance provided against these great Powers, and that the Air and other Fluids are bound by certain Laws of Weight, which are observed to be so different from those in solid Bodies? And whereas the last do only gravitate in proportion to their Weight, that in the Air, and other Fluid Bodies, as has been shewn before, a little Portion of 63 Pound in Weight, can hinder a Pressure of 180,000 Pounds perpendicularly, and
of

of about 900,000 Pounds laterally from exerting its Force.

Miserable Philosophers, who finding themselves preserved after so wonderful a Manner every minute of their Lives, against such dreadful Powers from sudden Death, and other frightful Effects; yet that they may not be forced to acknowledge with Gratitude, the Wisdom, Power and Goodness of their glorious Creator, will rather ascribe all to mere Chance, operating without Laws or Reason, or else to Causes wholly Ignorant of what they themselves are doing. In Case there were a Room of ten Foot in Length, and as much in Breadth, the Ceiling of which were made of Lead or heavy Stones, weighing 180,000 Pounds, which being loose on all sides, was only supported by a simple Balance, and thereby hinder'd from falling down upon the Floor and crushing every thing to pieces that stood in its way; and in case one should then put into the Hands of one of these Philosophers, a Weight of 63 Pounds, and with that only, and without any Mechanical Instruments (at least any that were made of a solid Matter) bid him Balance that mighty Weight, could he expect any thing else upon entering into a Chamber in such a Position, but the miserable Death of being crushed to pieces? And then if another Person, by inventing such a Method, could prevent the fall of this threatening and dreadful Weight with a Balance of 63 Pounds only, without any Mathematical Instruments; would he not, if he had the least spark of Generosity in him, own the Wisdom of the Inventor (tho' he could not discover the manner how) and extol it far above his own? And if he did not know the manner, but were at the same time sensible that his own Power was much too small to preserve himself by putting the same in Execution, Would he not think himself bound

to confess with Gratitude, the Power and Goodness of this his Preserver? And can he then live easie in these Circumstances, and without making any Reflections upon them? Can he, knowing the terrible Greatness of these Powers (with which he is surrounded, and which if the Ballance should cease to perform its due Functions, would threaten him with the same Dangers, and even with as unavoidable Destruction as if he were to have expected the fall of such a heavy Ceiling) still proceed, after he was so wonderfully saved, Blasphemously to disown the Preservation? And the more, since if he understands the use of the Barometer, the same would teach him, that these Gravitating Powers, as well as their Balances, are daily encreased and diminished by Causes, which if he does know, yet neither he, nor any Man living can prevent; so that it is impossible for him here to screen himself behind Laws of Nature fixed and immutable, and always observing the same Course.

And to say no more, when he must confess, if he reflects upon what follows, that this Gravity and Elasticity of the Air, is so entirely necessary to the Support and Convenience of Men, of Beasts, of Fishes, of Plants, that without the same, whatever lives upon this Globe would immediately Perish: And this Pressure of the Air, among all those Advantages which it imparts to all things, does likewise carry along with it this great Disadvantage, that it is capable of bringing the whole Earth, and every thing upon it, to the extreamest Confusion, by crushing to Pieces, and as it were annihilating all that it surrounds, with its resistless Power. Can he think that it is by Accident, and without Wisdom, that there is a Means found out, by which every one is permitted to enjoy the Benefits of the Air, and yet is so well secured against the pernicious Effects thereof; that this great Pressure, and
this

this terrible Weight, is in a manner insensible and unobserv'd even to the most tender Persons?

Once again, if all these Experiments about the Gravity and Elasticity of the Air, about its dreadful Force and wonderful Balance, by which the said Force is hinder'd from destroying every thing, be not sufficient to convince an unhappy Sceptick that there is a GOD, who in his Wisdom has brought it all about; let him go a little farther with us, and answer sincerely, whether seriously Reflecting upon all these things, he speaks with a Conviction of Conscience, when he asserts, that it seems to him to have come to pass by Chance, and without any wise Direction; that such a great Sea of Air has fixed itself round about the whole Globe of the Earth; which, if one may judge according to the most probable Opinions, is extended to some Miles in Height; and without which, every thing that Breathes, would give up the Ghost. And who is there that cannot say Experimentally, how much all humane and other Creatures are depending upon it? Which, tho' they are able to want both Sleep and Food for some Days, yet if they be depriv'd of this Air but some minutes, they will infallibly Perish. And how necessary the Air is to them, will appear particularly from hence: That during the whole space of their Lives, they are continually employed in breathing In and Out; so that both these Functions even at the time of Sleep (which does otherwise free them from all their Labors) must be incessantly discharged, and without any Rest at all, if they desire to Live.

Has there not then the hand of a wise Creator been visibly employ'd herein, who has made this Air for the support of Men and Beasts? To what purpose is their Body provided with such Instruments which serve alone to this, and to no other end, than to enable them to enjoy the use of Air? And, not

to repeat all that has been said before concerning Respiration, why have they *Lungs*, unless it be for the reception of Air? Why do they lye in that place, and in such a Disposition, that the whole Mass of Blood may pass so often thro' them, but that it might partake of the Operation of the Air? Why are the *Diaphragm*, *Ribs* and *Cartilages* of the Breast so framed, that their principal, if not only Function consists therein, to draw in and drive out this Air from the Lungs? To what end, that we may say no more, is this most ingenious Structure which that it may not be easily hinder'd in so necessary a Work, does employ about a hundred Muscles in that whole affair of Respiration? Why are most of the Instruments which are useful herein, formed already in a Child before it is Born, and at a time when there is not the least occasion for them, were it not that at the very instant when the little Creature comes into the Air, it should be able to use them for the support of its Life?

SECT. XXIII, and XXIV. *The Elastick Power of the Air is the Cause of Suction; confirm'd by an Analogous Experiment.*

IF the Air be produced by Chance; if it be by Chance also, that it is endowed with an Expansive and Elastick Power; it is then by the same Chance that any Child could ever suck a drop of Milk out of its Mother's Breast: For in case the Air, by the aforesaid Power, did not press upon all the Parts of the Breast, and cause the Milk to spring out of it at the time when the Child does, as it were with a natural Air-Pump, make a Vacuum in its Mouth before the Orifice of the Nipple, the least drop of Milk would not come out of it, by which means Young Children, and all other Sucking Creatures, would be bereaved of their best and most agreeable Sustainance.

Sustenance. Now, can any one imagine, that in the Structure of the Breasts of Females, and that of the Tongue, Lips and Cheeks of Children, there should be found such an Aptitude and Faculty of making use of the Elastick Power of the Air, in a Business of such vast Importance as is the Sucking of New Born Children, whilst there is no other so apposite and so convenient a Method for that purpose ; and that this Power of the Air, and the Adapting thereof to those Instruments employed by Children in Sucking, should be only Accidental, and produced by an Ignorant Cause, without any respect to such a Design ?

If a Man should look back to *Tab. XIII. Fig. 4.* and peruse again what we have said in §. 14. when he sees the Water B C, springing up in the Globe A B, exhausted of Air by the Pressure of the external Air, H K, upon the Water L M, he may observe an Operation Analogous and Uniform to that of a Childs Sucking ; especially if he will suppose the Part A B to be the Child's Mouth, and the vacuity form'd therein ; and the Superficies of the Water L M, to be the Breast of the Mother. And that he may be yet more fully convinced of the exact Agreement between that and Sucking ; Let him stop the Orifice D of the exhausted Globe with his Thumb, and he will feel something, which if he did not know how it happen'd, he would not Scruple to call Suction.

SCET. XXV. *Convictions from the foregoing Observations.*

To shew then, before we quit this Subject, the unreasonableness of the Atheist from the Pressure which the Air alone produces in Children's Sucking ; if he dares not maintain, that both the Pumps in

in a Fire-Engine, do by pressing the Water raise a mighty Stream thro' the long Leather Tube thereof, without being adapted to such a Purpose by the Contrivance of the Artificer, Can he with any more specious pretence affirm, that the Air, which by pressing upon the Breast, forces the Milk to flow out of it, has acquired such a Property by mere Chance to be applied to so much greater Uses as the administering Food to a new Born Child; and that not once (which perhaps one might affirm to be Accidental) but in all the Parts of the whole Earth, where Children, and so many thousand other Creatures are brought forth?

Once again, if this Elasticity and Pressure of the Air is to be ascribed to Chance only, they that maintain such an Hypothesis for Truth, ought to live in a continual Fear, that the same Chance may likewise alter the Air and deprive it of these Powers whereby they themselves, and every living Creature besides, will be suddenly Suffocated for want of Breath: For if all this comes to pass by Chance, and by the same Chance only is so continued to this very Hour, there is no reason to think but that it may be immediately alter'd by a like Chance; since it is of the very Essence of Chance to have nothing of Certain in it.

SECT. XXVI. *Experiments to shew that Living Creatures will Perish in a Place from which the Air is exhausted.*

Now that such an Apprehension would be very reasonable, appears; *First*, because we are taught by the Barometers, that (as has been shewn once before) this Elastick Force, whether it be from it self, or whether it proceed from a change in the Weight of the Air, may be often visibly diminished,
and

and upon that account the Quicksilver will subside. And *Secondly*, because a great Diminution of this Elastick Power of the Air is in a manner fatal to all Creatures; certainly to most of those upon whom it has hitherto been tryed. For Dogs and Cats, Rats and Mice, being placed under the Bell of an Air-Pump, are found immediately to be sick and out of order, as soon as the Elastick Power of the Air round about them is never so little diminished; and as it is taken away more and more, they dye in a small space of Time. But if you take them out before they expire, and place them in another Air, the Elasticity of which is greater, they will sometimes recover, especially if the Force of the Air be not too much diminished before. Birds are usually not able to withstand so long this Alteration in the Air; but generally fall into Convulsions which are presently attended with Death: Flies and Spiders (according to my Observations) after three or four Draughts of the Pump, seem to be wholly deprived of Motion, but when brought into the external and more gravitating Air, they begin to shew some tokens of Life again.

From these Appearances, and many more that you will meet with among the Modern Naturalists, it undeniably follows, that unless the Air were, thro' the Goodness of our Creator, preserved in its present State and Condition, whereby every thing breathing is saved from immediate Death; and in case that it were nothing but mere Chance, by which the Air, without being subjected to any higher Laws, is render'd one while Stronger, and another while Weaker in its Expansive and Elastick Powers, every body would be in a continual Dread, that he himself, and all living Creatures round about him would inevitably and immediately Perish; the rather, because several things, such as Steel and others, in which there is an Elastick

Rick Force discoverable, are often found to be entirely divested of the same, by remaining bent a long while, and so it would happen to the Air too, which, after such an Expansion, will not be able to restore itself to its former Elasticity and Springiness.

SECT. XXVII. *Atheists deny their own Principles.*

THIS being proved by so many Experiments, and yet we being unable to discover such a just Dread among the Atheists, it must undeniably follow, either, that thro' their Blindness they are hinder'd from observing the Consequences of their own Opinions, and therefore do treat this great Affair, which is of the utmost Importance to them, with so little Judgment and Understanding: Or, how boldly soever some of these miserable Philosophers may assert the contrary in Words, yet that they are convinced in their own Consciences of the Falseness of their Sentiments, and consequently are perswaded that it is by another Power, and not by ignorant Causes, they are preserved, even without and against their own Will; and thus they deny their own Principles.

SECT. XXVIII. *To Die in an Unelastical Air is no necessary Consequence of Nature.*

THAT it is no fixed Law of Nature, that every thing that lives in an Expansive and Elastical Air must immediately die when the Spring thereof is either weaken'd or totally destroyed, and therefore that these miserable Cavillers do torment themselves in vain to deduce this Appearance from the unknown Laws of *Matter* and *Motion*, or from a Necessity determining every thing, may appear

from hence ; that the contrary is true in the case of a *Frog*, as many other have observed, of which I find among my Notes, the following Experiment ; That a *Frog* being put under the little Bell of an Air-Pump, and the Air being exhausted from thence, not only the Belly thereof, in which one might expect there was Air, but likewise all the other Parts, as, Head, Legs, Muscles, &c. were swelled to a great Thickness ; which, upon the admission of the external Air, did all subside again, and the Creature return'd to its first Size ; but that which is most for our purpose is, that the *Frog* remained a quarter of an Hour in the Bell entirely exhausted of Air, without appearing to be the least affected with it, and when it was let out, immediately sprung away, as if nothing had ailed it.

SECT. XXIX. *To Die therefore in an Air divested of its Elasticity, is the Result only of the Will of G O D.*

CAN it therefore be denied, that since all Creatures are not equally affected with the Elasticity and Gravity of the Air ; what had been said before must not be admitted to be a general Law of Nature, which taking place between the Air and all Creatures, produces the Effects without Understanding ? And must not that Man be allowed to argue much more rationally, that does acknowledge herein the Hand and Work of a wise Artificer, who, that we may not ascribe that which happens to most of the living Creatures with respect to the Air, to necessary and unavoidable Consequences of ignorant Corporeal Motions, has been pleased by such an Exception as this, and perhaps by many others, to shew that all must be resolved into his good Liking and Wisdom ; and that he has thought fit that the Air amongst its other Properties

erties, should always preserve a certain degree of Force in its Expansion ; without which the whole Globe of the Earth would be in a manner deprived of all Living Creatures: And likewise, that when he thought fit to order it otherwise, he could preserve some of 'em alive without Air.

SECT. XXX. *The Elastick Faculty of the Air is not alone sufficient for the Preservation of Life.*

FOR the proof of this last Proposition, it may likewise be particularly serviceable to shew, that this Elastick Faculty of the Air is indeed necessary to Life, but that it is not sufficient alone : Thus we find in times of Pestilence, that the Air is sufficiently Elastical, but nevertheless Contagious and Fatal. And the great Naturalist, *de Stair*, relates, that not only many other Creatures, but likewise a *Frog* that can live in Air, in Water, and without Air, yet died in a little space of time with an Air or Steam that proceeded from Dough. And Experience does abundantly teach us, that a Living Creature shut up in the same Air, without any Circulation or Change therein, cannot long subsist so, altho' the Elasticity or Spring of the Air were not so much weaken'd as that we should ascribe the Cause thereto ; forasmuch as it appears by the Barometers, that the Air by which we are surrounded, can undergo great Alterations in its Elastick Faculty, without any Prejudice to breathing Creatures. But of this Property of the Air, which, besides its Gravity and Elasticity, is necessary for the support of Creatures, we have already said something in our Discourse upon Respiration.

SECT. XXXI. *The Elastick Power of the Air does likewise cause Fish to live and subsist under Water.*

BUT before we take our Leaves of Living Creatures, can any one observe without Astonishment, that even the Fish in the Water do receive their Life and Well-being from the Pressure and Elasticity of the Air? which being removed or taken away, scarce any of 'em can contain themselves under the Water, but in spite of all the Resistance must emerge and rise up to the top of it.

They that would see the Experiment of it, may put some Water and a Gudgeon, or any other little Fish, into the Recipient of the Air-Pump; and removing the Pressure of the Air, will find that a Fish immediately rises up to the Top, but upon letting in the Air it will sink down again. The Reason thereof, and how the Bladders within their Body are dilated by the diminution of the Air's Pressure, and by becoming larger, do render the Fish so much lighter than Water, whereby they ascend, shall be more fully treated of hereafter, when we come to consider the Nature of Beasts, &c.

Now since most Fishes are of so wonderful a Structure, that they can and must make use of the Pressure of the Air, in order to remain under the Water, and in such Places as are most convenient for them, without being forced to Ascend or Descend against their Wills; and that all of 'em, without such a Pressure of the Air, being forced to the Top of the Water, would soon be destroyed; let us draw this Conclusion only here, that he must be a very strange Person that shall maintain, that the Air and its Pressure, so very necessary in this case, is produced upon the Earth by meer Accident, and without any view towards so useful an Operation; and that the Fishes are likewise

wise exactly formed after such a manner, as to be provided with Instruments by which they can encrease or lessen the quantity of Air, for the aforementioned Purposes.

SECT. XXXII. *Plants do also live by Air.*

THE Air is not only of such great Use to Men, Beasts and Fishes, but even to Plants themselves, which vegetate thereby in such a manner, that a great Part of the Sap with which they are nourish'd, is compos'd thereof. Wherefore, in case Men could have lived even without Air, yet they could not have enjoyed sufficient Food from the Earth without it, because it contributes so much to the Fertility thereof, which is well known to the Husbandmen, who for that reason Break up and Plough their Lands so frequently, in order to expose them to the influence of the Air.

However, if what we have here said be not clear nor intelligible enough to any one, namely, that Air insinuates itself into Plants, and that they cannot grow without it, they may consult those accurate Enquirers into the Nature of Plants, *Malpighi* and *Grew*, concerning the Air-Vessels which they have discover'd therein by the help of Microscopes; and *Boyle* and *de Stair*, concerning their Observations with the Air-Pumps; these Gentlemen having shewn, that Air can be drawn out of Plants placed *in vacuo*. But he that would have ocular Demonstration thereof, let him take a little piece of a Twig from a growing Tree, or Green Leaves cut asunder, and other Parts of Plants, and tie them to a Nail, or any other heavy Matter, and put them into a Glass in which there is Lye, made of Salt of Tartar, or Pot-ashes, in order to make them sink down into it, then putting them all together under the Bell of an Air-Pump, and

exhausting the Air out of the Bell, he will presently see the Air coming out of the Ends that were cut off from the Plants in numberless Bubbles, and rising up to the top of the *Lye*; at least it happen'd so in all the Experiments which I have had occasion to make in this Matter; and from some of them particularly, as from the Twig of an Elm-tree, I observ'd a much greater Stream of Air than can easily be believed by those that had never seen the same.

The reason why we rather prescribe the use of *Lye* than of Water in these Experiments, is, because no Air will mix itself with the former, tho' it be never so long expos'd in an open Vessel. You may use Water also, after you have boiled it so long, till all the Air be evaporated, and let it stand till it be cold again.

SECT. XXXIII. *Fire is maintained by Air.*

ADD to what has been said, that Air has this Property likewise besides all the rest, that Fire (which, without all Contradiction, is one of the most useful things that is known to Man) cannot be supported without Air; at least, that kind of Fire that we commonly make use of: So that for want of Air almost all Fire will be extinguish'd in *Vacuo*, or in any Vessels into which one puts live Coals and closes them therein. Now how many Inconveniences would befall the whole World, if we had not the use of this glorious Creature, but should be bereaved of its Warmth in Cold Weather, of its Light in Darkness, and of many other Advantages it brings along with it: But we shall say no more of it here, because we design to treat of it more expressly in our Discourse upon that Element.

SECT. XXXIV. *Air causes Smoak and the Particles thereof to ascend.*

THIS is certainly true, that if the Pressure of the Air did not cause the Smoak of all things that are burnt with Fire, of all putrified and rotten Matters, and other disagreeable Vapours perspiring from solid or fluid Bodies, to mount up like Oyl in Water, the same would render the surrounding Air foul and unhealthy to us: And how would Mankind be refreshed with that vast number of sweet-scented Flowers and Plants with lovely Perfumes and Spices, if the Creator had not endowed the Air with a Property of conveying to the Instruments of Smelling, all those Exhalations which we endeavour to discover and enjoy by the help of that Sense?

SECT. XXXV. *Air is the Cause of Sounds.*

BUT that which shews in the plainest manner the Obligations of the Thankfulness we lye under to the Great Creator, is that those wonderful Instruments of Hearing, notwithstanding the most wise and artful Contrivance thereof, would have been implanted in Mankind and all other Living Creatures in vain, and without any manner of Advantage, unless the Air by its Motion had been endowed with a Power of producing Sounds: For how miserable all Men would have been without Sounds, and consequently without Hearing, has been already proved in our Contemplation upon the Senses.

SECT. XXXVI, and XXXVII. *Several Experiments to prove the Production of Sounds by the Air.*

IT is not now our purpose to enquire here what kind of Motion, or what Parts of the Air produce Sound. This seems to be certain, that it is a Motion of the Air's Elastick Particles; for upon exhausting these Elastick Parts of Air suddenly from the Glass Globe A (*Tab. XII. Fig. 4.*) and upon their protruding one another towards the space of the empty Pump, we could observe a Sound or Noise, which, when the Bell was full of Air, and the Spring of the Air more strongly dilated, that is to say at the beginning of it, is loudest, but upon evacuating the Bell, and consequently upon weakening the said Spring, or perhaps also, upon lessening the number of the mov'd Parts, the Sound is gradually diminished.

Thus we find by hanging a little Bell within the Receiver and pumping the Air out, the Sound of the same becomes much weaker. A Striking-Watch shut up in the Receiver of an Air-Pump, and fasten'd to a String, is not heard so plain as when it is out of the Bell; but upon exhausting the Air, the Sound was so much and so sensibly diminished, that it could scarce be heard at all. But as far as I could ever yet learn, no body has been able to exhaust the Air so far, as that the Sound of a Clock or Bell should not be heard at all: Unless it were only Mr. *Huygens*, who in his *Traité de la Lumiere*, p. 10. informs us, that he placed a Clock upon Feathers or Cotton, to the end that its tremulous Motion might not be communicated to the Glass in which it stood.

And it is likewise observed, that a Place in which the Elastick Power of the Air is much weaken'd, or from whence the Air is exhausted,
made

made in the middle of the common Air, and an opportunity afforded to the said Air, to be push'd in from all Parts thitherwards by its Elastick Force, so that its Parts strike against one another, a great Noise is caused thereby; for in case one should put the two half Copper Globes, which are commonly made use of in Air-Pumps, upon one another, and stopping them very close, should pump the Air out of 'em, and so make the hollow space therein, to contain but very little Air, and that much weaken'd too; and if then those Hemispheres or half Globes, be suddenly drawn asunder with a great Weight, and thereby an opportunity given to the Parts of the External Air to strike against each other, we shall find a Noise produced thereby, like the discharge of a Gun.

The same has been likewise remarked above in the breaking of the Glass (*Tab. XIII. Fig. 3.*) by swiftly forcing in and compressing the Air into the Copper Vessel A B C D, out of which at K, there was some Part exhausted, and consequently the Elasticity of the remaining Part was weaken'd in Proportion. As it also happen'd, when instead of such a Copper, an octangular half Pint Bottle was placed upon the Mouth O, of the Copper Plate H I, and a little Air exhausted from the same; whereupon the Glass burst into small Pieces with a loud Report, thro' the Pressure of the External Air: To prevent the Danger that may accrue from thence, the best way will be to cover the Bottle with a Bladder fasten'd about the neck thereof.

SECT. XXXVIII. *Convictions from the foregoing Observations.*

WE shall not here enquire farther what probable Conclusions may be deduced from these and other Experiments, concerning Bodies yielding Sounds thro'

thro' the particular Motion of the Parts of the Air ; but this may be safely affirmed, that without Air, little or no Sound would result from the Motions of Bodies. Now can they that know the necessity thereof, maintain such a sort of Philosophy, as teaches that the Faculty with which the Air is endowed of conveying Sounds and Smells to our Ears and Nostrils, is only owing to Chance, without any View of being serviceable to Mankind?

SECT. XXXIX. *The Use of Air in Pumps.*

BESIDES all these wonderful Uses and Services daily render'd by the Air to such as inhabit this Earth, a great many more might be mention'd ; And ought not then every Body that has any Sense of Generosity, acknowledge how much he is bound to give thanks, when he, without contributing any thing thereto on his own Part, finds himself surrounded with so vast a Force and Pressure of the Air, which he can make use of according to his own Pleasure, in so many Occasions for his Conveniency, and that he may not be troublesome to himself or others ?

Every one who knows, that Pumps and Fountains, and such like Hydrostatical Instruments are only render'd useful by the Pressure, that is by the Gravitating and Expansive Power of the Air, which, by the Art of Man, has been applied thereto, will be fully convinced of the Truth of this Proposition.

And those who are ignorant of it, may consider the Spout or Syringe, A B C, *Tab. III. Fig. 3.* (of which mention has been made above in *Contemplation VII. §. XI.*) as a Barrel of a Pump standing in the Water D C E ; in which Pump, as has been there

there shewn, no Water will ever ascend, tho' you should draw the Sucker F upwards, unless the Air G do gravitate upon the Water D E. Now that a Pump on this occasion may be look'd upon as a kind of Syringe, is known to every Body.

SECT. XL. *The Air contains fermenting Humours in its Vessels.*

THAT there are so many fermenting Liquors, such as Beers, Wines, &c. working in themselves, used by several Nations for their Pleasure, Refreshment, and other Ends, we ought thankfully to confess to be owing to the Goodness of our Creator; who, by placing the Air upon this Globe, and endowing it with a Gravitating and Elastick Faculty, causes those Liquors to stay and remain within their Vessels, which, without such a Pressure of the Air, they would burst to pieces, or run all out of the Mouth thereof: They that have a mind to make a Trial of it, let them take a Glass of our Common Beer, that has done Working, and is some Days old, let them place it in the Receiver of an Air-Pump, and exhausting the Air, they will presently see it rise and Froth, and run over the Brims of the Glass like Bottled Beer: But by letting in a little Air again, it will presently subside, and cease Frothing and Working.

To take no notice, that unless the Pressure of the Air did put a stop to such Working, the drink would immediately lose both its Strength and Agreeableness, as every body knows that has tasted Beer after such Working, whereby it is render'd as flat and insipid as if it had stood a great while exposed to the open Air.

The good Wives ought likewise to be informed, that without this Pressure of the Air, no boiling Water will stay in their Pots and Kettles. They
that

that doubt thereof, let them set a little Tea cup full of hot Water under the Bell of an Air-Pump, then draw off the gravitating Air, and they will find that the Water will run over and dilate itself almost like Gun-powder that is set on Fire.

SECT. XLI. *Refraction and Twilight, or Break of Day.*

NOW as most of the Effects we have already mention'd concerning the Air, are produced by the Gravity and Elasticity thereof; altho', towards the Respiration of Living Creatures, towards fertilizing the Earth, and perhaps too towards the Nourishment of Plants, and other Matters which are brought to pass by the Air, there seem likewise to be some other Faculties and Parts requisite in the same; I say, besides all this, it does yet render one eminent piece of Service to the whole World, and that upon account of being compos'd of a fluid Matter, thicker than that which is above it, viz. that by the *Refraction* or Breaking the Rays of the Sun in the said Air, the *Twilights* of Morning and Evening are produced; whereby a clear and full Day is prevented from being turned oftentimes in a very little time into a Night as dark as Pitch in the Evening, and so again a dark Night from being turned all at once into a bright Day, to the visible Prejudice and Weakening the Eyes of Men, and all other Creatures; it being sufficiently known to all that have tried it, how troublesome and inconvenient are such great and sudden Changes from thick Darkness to a strong and clear Light.

'Tis owing to this Property of the Air, that the Countries which lie near the Poles, during their long and dismal Nights, do participate of the comfortable Light of the Sun many Days before it rises above the Horizon: From hence it proceeds like-

likewise, that those Nations which lye far from the Poles, and in which the Sun daily Rises and Sets, do discover sooner, and are deprived later of the welcome Light of Day, which they therefore enjoy much longer than if there had been no such thing as Air about this Globe of the Earth.

To give the Reader some Notion thereof; Suppose NZS , to be the Globe of the Earth in *Tab. XIV. Fig. 3.* $EWH T$, the Air surrounding it, and EY , the visible Horizon of those People that dwell at F : Now if there were not between the Air and the Sun A , such a thick Matter as the Air itself, and the Ray of the Sun AH , falls upon it, the Mathematicians know, that it must be remarked as falling upon the Line BC , which touches the Air at H , and consequently upon the Air in this, having some Obliquity, as making with the same the Angle AHC .

Now it has been shewn above, when we treated about the *Sight*, in *Contemplation XIII.* That a Ray (*Tab. X. Fig. 2.*) coming upon a thicker Matter, which is likewise transparent, does not run streight forwards to D , but is inflected to the Perpendicular GQ ; and being bent or refracted at H , is diverted into another Course HF , so that in *Tab. XIV. Fig. 3.* this Ray of the Sun AH , by such an Inflection, may reach the Eye of one that stands at F , whereas it would otherwise have passed a great way above him at D .

It is likewise plain by Optical Experiments, that a Ray, according to the Right Line HF , falling upon the Eye, the Person that sees, does always fancy to himself that the Object is in the Ray FH , for which reason, the Sun A being really under the Horizon EY , they that live at F , think that they see the same in the produced Line FH , that is at R , and above the Horizon.

Now

Now that this is so, has been briefly shewn above in *Contemplation XII. Tab. X. Fig. 4.* and from thence it may, in some manner, be comparatively known how the Rays of the Sun, being refracted in the Morning and Evening Twilights, do enlighten the Earth, and cause us to see the Sun before it be really Risen, and after it is Set.

SECT. XLII. *Convictions from the foregoing Observations.*

NOW can the unhappy Atheist fancy again, that this Property of the Air, with respect to Light, is likewise produced accidentally? Whereas he is nevertheless forced to acknowledge, that it is so great a Benefit to himself, and the rest of the Inhabitants of the World, that in case he had the ordering of it himself, he would think that the Advantage which he had acquired from this one Property of the Air, was alone worth the while to encompass the Earth with such a Body.

SECT. XLIII. *The Gravity and Elasticity of the Air unknown to the Ancients.*

BEFORE I quit this Subject, I cannot forbear saying something very remarkable for the Comfort and Confirmation of such as have not so far forgotten GOD, as to deny the Perfections and Attributes of that adorable Being, by whom all things have been produced; let such therefore consider, that the Gravity and Elasticity too of the Air, are new Discoveries, being accordingly term'd by the Gentlemen of the Royal French Academy, in their History for the Year 1702, the first Discoveries made by Modern Philosophy about the Nature of Light, That they were unknown

known for so many Thousand Years to the most diligent Enquirers into Nature, and continued a perfect Secret, even to the most Learned Philosophers, till the last Age. For they, and all the Ancients, look'd upon the Air to be a light Body, which would ascend of itself, at least, that it was without Gravity or Weight, to speak of that Property in the first Place ; till in the last Age, the Invention of *Barometers*, together with the subsequent Experiments made by the Air-Pump, Fire, and otherwise, did furnish us with undeniable Proofs, that the Air is a heavy Body, and that we are able to compute the Weight thereof. Add to this, that the *Barometer*, (the first Instrument that has given Men a Notion of this Gravity of the Air) was not discover'd either by the Study or Penetrating Judgment of the Inventer, *Torricellius*, who had not this in his View by any Means ; but (to use the Words of Mr. *de Stair*, *Physiolog. Expl. XIX. Sect. 41.*) was revealed by the Divine Providence in the Year 1643, and as to him, entirely beyond his Expectation.





CONTEMPLATION XVIII.

Of METEORS.

SECT. I. *Transition to the Meteors.*

BEFORE we take leave of the Air, it seems requisite to say something concerning *Meteors*, such as the *Clouds*, *Mists* or *Fogs*, *Wind*, *Rain*, *Thunder*, *Lightening*, &c. ; forasmuch as an infinite Number of Wonders have at all times appeared therein ; and the Almighty has thereby, in a particular manner manifested his Tremendous Power and Greatness many times to those, who as far as in them lay, endeavour to deny it ; and forc'd them to own it with Fear and Trembling : Yet forasmuch as the same are mostly placed out of the reach of such Experiments as might serve either to make a just Enquiry into all the Causes thereof, or even to try the Certainty of some probable Opinions concerning them ; Humane Knowledge does not extend itself far enough in these Matters to be able to say with sufficient Certainty, how they are produced, and how they operate.

SECT. II. *The Air is a Menstruum or Dissolving Fluid.*

THIS seems however to be true, that the surrounding Air has the same Power and Effects upon many Bodies, as that which the Chymists call a *Menstruum* or Dissolving Liquor ; upon which it operates after the same manner as *Brandy*, for instance,

stance, upon Spices put into it, out of which it extracts some of the Parts and incorporates them with itself.

SECT. III. *The Air is impregnated with great variety of Particles.*

THUS we see, that all the Effluvia or Exhalations of such an infinite number of Bodies; that all the Scents; whether of sweet or stinking Bodies; the Smoak and Steam of things that are burnt or putrified, the Vapors and Fogs arising from so many Seas, Rivers, Lakes, Ponds, and other Waters; the Particles of Fire from so many Flames, of Nitrous and Sulphureous, of Acid and of Alkaline Bodies, or of both of them fermented together; in a word, whatever they call Volatile, and which being exhaled 'can ascend, are all mixed with the Air, and collected in the same, as in a common Magazine or Ware-House. Add to all these the Rays and Light of the Sun, that move with so unconceivable a Swiftneſs, as we shall show hereafter, and which are reverberated, or do rebound back into the Air in infinite Streams and Numbers. To say nothing of the Planets and fix'd Stars, which how little Effect soever they may be supposed to produce by reason of their vast Distance, yet, since these Heavenly Bodies are seen thro' the Air, and the Rays are transmitted with a prodigious Velocity quite thro' it down to us, we have reason enough not to pass them by in silence. To reckon every thing would be impossible, and they who are never so little conversant in the Experiments of Natural Philosophy, will readily agree to this mixture of an infinite number of different Particles.

SECT. IV. *The same proved in Sulphureous Particles.*

THAT we may give an imperfect Sketch thereof, to such as are Ignorant and Unexperienced; and passing by those Effluvia or Vapors that rise from Water, as being too common, that Sulphureous Particles are mixed with the Air, may appear from the Scent or Smell of Brimstone that attends Lightening sometimes; besides that, several Accounts teach us, that they ascend from the *Volcano's* or *Burning Mountains* in vast Numbers, into which they are dissolved by the means of Subterraneous Fires, after the same manner as it is done in Chymical Operations: And this is also plain from hence, that even here in our Watry Country, there are Pits or Wells over which if you hold a Candle, the Air will immediately be kindled, insomuch, that whole Houses have been consumed by the like means; and not long since, a Person was miserably Burnt in that Country which we call the *Beemster* in *North-Holland*, which is nothing but a drained Meer or Lake.

SECT. V. *The like Mixture with Particles of Fire.*

THAT Fire mingles itself with Air, appears by many Experiments, such as Lightenings, as also, that Matter, which the Chymists call a *Phosphorus*, which having lain many Years under Water, and being taken out from thence, immediately shines in the Dark; and with the least Warmth (even so small that it can hardly be called hot) it will burn so, as not to be extinguished. Such a *Phosphorus* is distilled from Humane Urine, after it has stood so long in the Air till it is corrupted: And some who have tryed it say, that in case such Urine can be kept where no Air can come at it, notwith-

withstanding it be so Chymically prepared, it will neither Shine nor Burn.

SECT. VI. *Alkali's and Acids mixed with Air.*

THAT *Volatile* and *Alcaline Salts*, such as those that are extracted from Soot, Harts-horn, &c. are dissolved in the Air, is well known to those who have smelt of the same, and have often learned to their Cost, that such Salts are in no wise to be preserved long; and Glass Phials filled with these *Volatile Salts*, and not well stop'd, have frequently been found quite empty, or at least have lost a good Part of them. The same has been observed as to Acid Liquors, by the sower Smell that exhales from them, such as Vinegar and other things: Infomuch, that if you set any Acids under a Copper or Brass Plate, the Vapors that exhale from them, and mingle themselves with Air, will eat thro' such Plates, and turn them into a *Spanish Green*. Moreover, in distilling Spirits of Saltpetre, which comes over without any Water, we know that all the Stopples that are used to the Phials that contain 'em, are corroded by the Particles that ascend into the Air; and that the said Spirits being put into an open Bottle, do frequently emit visible Effluvia.

SECT. VII. *Burning Spirits and Oyls mix themselves with the Air.*

THE Air is likewise impregnated with *Burning Spirits*. This is known to every Body that has warmed good Brandy, and held a burning Paper or Candle near the Steams of it; of which those that are in the Air are immediatly kindled. The same Experiment is made by the Chymists in their Distillations, when they try whether their *Lutums* (that is

the Matter which they apply to the Joints of their Vessels) are as close as they should be; for if one holds a Candle to them, and any of the Effluvia come out, those that pass into the Air thro' the *Lutum*, will immediately take Fire.

Oils themselves will mingle with the Air. Wherefore, to say nothing of Train-Oil, which can be smelt so far off (forasmuch as some may doubt whether they be the oleaginous Parts themselves that affect our Nostrils) let any one take Oil of Olives mingled with Salt, and distil it with a glowing Iron Pot, upon which there is an Iron Helm, with an Orifice or Hole at the Top, so as it may be shut with an Iron Cover, he will find when the Cover is taken off, in order to take some of that Matter with an Iron Ladle out of the Pot, and to put fresh therein, that the Steams (which being drawn over into the Recipient, do there make what they call an *Oleum Philosophorum*) as soon as they come into the Air, flame out, and so continue till the Orifice of the Helm be again closed.

SECT. VIII. *Other Particles do likewise mix themselves with Air.*

AN infinite Number of other Particles, besides those of which we have given Instances above, are found to incorporate themselves with the Air, as with a common Menstruum or Dissolvent, accordingly it is observ'd by *Varenius*, in his *Geography*, (*Lib. I. Cap. XIX. §. 41.*) that when the Spices in the *Indian* Islands are ripe, the Seamen know it by the Smell thereof, at the Distance of three or four Leagues: That in the Islands named the *Azores*, the Air is impregnated with so many Acid Particles, that it corrodes even the Iron and Stones of Houses, in such a manner, as to reduce them to Dust in a little time: Whereas, on the contrary, in the

Province

Province of *Chili* in *America*, the Air is so soft, and that tho' one put up a Sword without cleaning it into the Scabbard, there will never be found any Rust upon it. They that would be further inform'd upon this Subject, may consult the Author in the place we have quoted.

SECT. IX. *Many Particles preserve their Properties in the Air.*

AFTER all this, no body I think will scruple to acknowledge the Air to be a Menstruum impregnated with an infinite Number of Particles; only it seems necessary before we proceed, to shew, *First*, That the Effluvia of such a great Number of solid and fluid Matters, tho' dissolv'd in the Air, may yet preserve the same Properties which they had before they were mingled therewith. They that desire sufficient Instances thereof, may see what that great Naturalist, Mr. *Robert Boyle*, has writ about them in his Discourse on the determinate Nature of Effluvia. This however has been experimentally observed, first in fluid Matters from a great many Distillations of Waters, of Burning Spirits, of Acid Spirits, of Spirits that have Volatile Salts in them, of Quicksilver, and almost all such like Liquors, which evaporating in the Air by Warmth, do therein so very much maintain their own Figure, that being admitted into a Recipient, and turned again into a Liquid Matter, almost all of them yield the same Fluid of which they were compos'd before they were mingled with the Air.

The same may likewise be observ'd in many solid Bodies, which the Chymists do raise, or (as they Phrase it) sublimate by Fire. Thus, according to the Report of the aforesaid Mr. *Boyle*, who ought never to be named but with Respect, Sul-

phur, Camphire, Benjoin, Sal-Armoniac, and even a Metal as heavy as *Tin*, may be sublimated and mix'd with the Air by the Heat of Fire; and the Parts thereof may be again changed into a solid Body, with the same Properties it had before.

And let no Man imagine that we draw out this Analogy too far, because they are not sensible of such a Heat, or of such Fires in these Climates, as might seem sufficient to dissolve these Bodies, and to cause them to evaporate into the Air, to perform which, so intense a Heat is required in Chymistry: For whoever has read any thing concerning the Subterraneous Fires that shew themselves in burning Mountains, and with how much *Sulphur, Ashes*, and other Matters, they have often filled the Air, even at the remotest Places, will find that there is not the least room to doubt thereof.

SECT. X. *The aforementioned various Particles, by their Operating upon each other, do produce both Wholsome and Unwholsome Airs.*

FROM what we have shewn already, it will follow, *Secondly*, that he who knows how variously and powerfully these Particles, floating in the Air, do operate upon each other, will easily conceive, that from the different Conjunctions and Separations thereof, different Qualities of the Air does likewise result. Insomuch, that some of the Parts being wholly Innocent in their own Nature, by their Conjunction and Mixture with each other, may become hurtful and even fatal; and so on the contrary, those that are Prejudicial may likewise become Healthful, and thus in many Cases they may undergo many Changes.

SECT. XI, and XII. *Several Experiments hereof.*

THUS we see (to give an Instance of what we have asserted) that the Spirit of *Common Salt* and *Mercury*, neither of which are poisonous alone, being sublimated by Fire, are united in the Air, and then become such a deadly Poison (to which they usually give the Name of *Sublimate*) that if it do not exceed *Arsenic* or *Ratsbane* itself, it may be counted at least as fatal. We shall not here enquire, Whether what has been observed by *Diemerbroek*, *de Peste*, *Lib. II. Cap. 3.* might be supposed to have happen'd after such a manner, namely, that the Fumes of *Soap* with which *Linnen* was washed, might have brought the *Plague* into the Houses of *Nimeguen*, and have render'd the Air of that Town contagious, tho' it is well known that the Ingredients of which that Matter is composed, have nothing Pestilential in them. This is hardly to be doubted, that when the Subterraneous Fires in the Times of Earthquakes have filled the Air with many Exhalations, those Exhalations themselves, or their Union and Co-operation upon other Particles of the Air, have often produced Contagious and other Epidemical Distempers.

Thus we also see that great and pernicious Poisons floating in the Air, being joined to other Matters, do thereby lose their pernicious Qualities. And the Chymists know very well, that how often soever the aforementioned *Sublimate* is exhal'd or raised up into the Air, it will still remain a deadly Poison: But if one take an equal Weight of Salt of Tartar, and mix it therewith, and then evaporate both together, their Parts will unite themselves in the Air, and losing their poisonous Faculty, will produce a Medicine called *Mercurius Dulcis*, which is very

good in many Cases. Some ascribe it to the same Cause, that the Plague ceases at *Grand Cairo* as soon as the River *Nile* begins to swell; so that whereas the very Day before there might die 500 Persons, the very next Day there would not perhaps die one, according to the Relation in *Sandy's Travels*, Lib. II. The abovemention'd Mr. *Boyle* confirms the same by many Instances.

That Gentleman has likewise taught us Experimentally, that fluid Bodies may be changed into solid in the Air; viz. by putting the Spirit of corrupted or fermented Urin to Brandy, which has not been entirely separated from its Water, and setting it over the Flame of a Lamp, or some other more gentle Heat, that the Fumes ascending from thence are turned into a solid Body in the Air, appearing at the Top of the Glass, like a fine white *Sublimate*, notwithstanding, that before the Distillation, each of them were a liquid Matter.

It is not our Design in this place to enquire so strictly, Whether the abovemention'd Phænomena at *Nimeguen* and *Cairo*, were rather to be ascribed to a Precipitation or Coagulation, which some of the ascending Particles might produce in the Air; but that something of the like Nature may happen in the Air, whether by Conjunction or Separation, seems to be maintainable in some manner, from the Observation of the Professor *Schagt*, at the time of the Sicknefs at *Leyden*, of which mention has been made before in *Contemplation VII.* and that which has been related to me by a curious and observing Gentleman, seems to confirm the said Opinion, which he says was commonly known to all the Inhabitants of *London* at that time, namely, that in the dreadful Pestilence of the Year 1665, those *Coffee-houses* that were continually filled with the Smoak of *Tobacco* were almost the only places that escaped the Infection.

I shall

I shall not pretend to determine, whether what we have just now mention'd, must be understood to happen after the same manner, as when a good quantity of *Sublimate* is dissolved in Water, and when into the same Liquor, which is very poisonous, Salt of *Tartar* likewise dissolved in Water is poured into it, so long, till a reddish Powder is produced and sinks down to the Bottom, or, according to the Chymical Term, is *precipitated*; after which it will appear, that by the Operation of these two Matters upon each other, all the Poison of the *Sublimate* will be done away : Or, whether it may be supposed to happen in Conformity to that other Experiment, and the Consequences thereof, in making of *Mercurius Dulcis*, as has been observed above. Our main Design in all this, has been only to shew, that upon considering the whole Matter, we ought to suppose this Globe of Earth, with its surrounding Air, not only to be a Mathematical Machine, which may be proved by other Experiments, but moreover as a great *Chymical Laboratory*, in which the Air represents a Recipient, in which thousands of Kinds and Differences of exhaling Particles are collected, either by Subterraneous Fires, by the Heat of the Sun, or by some other Causes : Or otherwise, as a *Menstruum* and Dissolvent, which being poured out upon innumerable Matters, extracts and unites to it self various Particles from each of them : And those Particles being mingled with the Air, may variously operate upon each other, according to their different Natures and Properties.

SECT.

SECT. XII. *Convictions from the foregoing Observations.*

BEFORE we proceed any further, in case any body, be he who he will, that has formed a just Notion of this Constitution of the Air from what has been said already ; and that knows what an infinite Number, not only of the same, but even of different Kinds of Particles, do occur in the Air ; after how many various manners they unite with each other ; how from their Conjunction, from their Division or Separation, and otherwise, so many pernicious and fatal, as well as wholesome and useful Effects may result ; I say, if besides all this, he is assured, that without Air neither Animals will live, nor Plants grow ; Can he sit down easie under a Perswasion, that all things do thus come to pass either by Chance, or by Mechanical Causes, entirely ignorant of what they are doing, and without any Wisdom or Design ? And that without an infinite over-ruling Power and Providence, this real *Chaos*, or confused Mish-mash, subject to such an unspeakable number of Alterations, by the multitude and disagreeing Properties of its Parts, could have been adapted for so long a Time, and still continue so, to preserve alive so many thousand Animals and Plants, and to furnish all that is particularly necessary to every one of them, with so vast a variety ? And, can he imagine, that it is to be ascribed to any thing but a Divine Direction, surpassing all understanding, that these things do not fall into the utmost Confusion ? Yea, can he possibly, with all his Wisdom, form any just Idea thereof ? How from such a confused Mixture of all kinds of things as the Air is, and among which many indeed are serviceable and useful, but likewise many others, both prejudicial and even contagious

tagious and Fatal ; I say, that each requisite Particle can discharge its Function in its Place, and all the bad ones be prevented from doing harm ; were it not that the Supreme Will of our Adorable Ruler did herein exert its Wisdom and Power.

SECT. XIV. *The Invisibilty and Inspidity of the Air very Useful.*

THE aforesaid Wisdom and Goodness of GOD has often occur'd to me with great Astonishment, when I consider'd, that he has been pleased to subject to our Sense of Seeing, *Fire, Water, Earth, Sun, Moon, Stars*, and almost all other Creatures, excepting only the Air, which tho' we can feel well enough in Winds, and other Cases, yet he has thought fit to render invisible to us. And yet, how does almost every Man tremble when he sees the Vapors and other active Particles therein, gather'd together in dark Clouds, and threatening us with Thunder and Lightening, with Storms and Tempests ?

Again, If any one should be obliged to drink the Waters of *Fens* and *Marshes*, of *Ditches* and *Kennels*, mixt with Dirt and Nastiness, tho' perhaps not otherwise Pernicious, how loathsome would it appear to him ? Or if he should meet in it any of the *Spawn* of *Serpents* or *Toads*, tho' there were not enough thereof to Poison him, yet with how much Fear and Terror would he take the Cup into his Hands ? And what Pains would he take to separate what was Pure and Wholsome from this dreadful Composition ? Now, if in the same manner, all the Filthiness that is to be found in the Air, all the exhaling Particles, from foul and nasty Places, all the Vapors from stinking Puddles, or from rotten Carrion, or dead Carkasses, all the ascending Steems from poisonous Minerals, and
contagious

contagious Animals or Plants, all the disagreeable Effluvia from the Bodies of Men and Beasts, and whatever else of other Infections in the Air might be added hereto : I say, if all things were set before his Eyes in the same manner, would he not loath and nauseate the very sight of them ? The same would certainly befall him, if he were capable of seeing with his Eyes, the Air that he must constantly breath, filled with so many impure and unwholsome Particles ; would he not live in a continual fear of being poison'd by them ? Would he not employ all the Powers of his Mind, even till he was tired, to find, if it were possible, among such a loathsome heap of disagreeable Things, something that was clean and could be suckt in without Nauseating ? Should we not see the Rich Men offering more Money for Places where the Air was pure and wholsome, than they now bestow for Stately Houses and Country Seats ? Now it has pleased the gracious Director of all things so carefully to provide against these Inconveniencies, (that what befalls us every moment of our whole Lives, namely the *Inspiration* and *Expiration* of Air, might be performed with Pleasure, or, at least, without producing in us any disagreeable Sensations,) as to render invisible to us, that Air which would otherwise set before our Eyes a perpetual Swarm of detestable Objects ; and by this means only (tho' they should not be dangerous to our Health or Life) release us from incessant Cares and Fears, of drawing into the Lungs by the Mouth and Wind-pipe such a quantity of odious Things.

The like Aversion and Dread of so many Particles floating in the Air would befall us, but in a much higher Degree, if they should become sensible to our Taste. Ought not then every Man to acknowledge his Obligations to the Wisdom and Mercy of the great Ruler of this World ? Who, tho' he
causes

causes us to *Hear* this compounded Air in *Flutes* and *Organs*, to *Feel* it in *Winds* and *Storms*, and to *Smell* it too in many Cases; yet, that he might not make us miserable, has form'd it after such a manner, that notwithstanding its being impregnated and laden with such a diversity of Parts, it can be neither *seen* nor *tasted*, except in some particular and very rare Cases; by which an Atheist may be convinced, that he who brings this about, does it of his free Will and Pleasure; but by no means can it be said to be thus order'd by necessary Consequences, and much less by Chance. Accordingly we find, for instance, that when an Apothecary has pounded a good quantity of *Aloes*, and that the finest Parts thereof fly up and mingle themselves with the Air, their Bitterness discovers itself to the Taste of those that suck in that Air: And to shew, that the Air is likewise in its own Nature visible, we need only compress a good quantity thereof together in an Air Pump, and then let it out again as quick as we can, and it will presently shew it self to our Eyes like a *Fog* or *Mist*.

SECT. XV. *The Observation of Meteors resumed.*

BUT to return to the *Meteors*; If we should attempt to shew the Causes thereof fully and clearly, we must do it by a number of Natural and Chymical Experiments, which might be render'd Analogous and Uniform to the same in Little; but this would engage us in too large a Field; we shall however produce some few, to shew how the same are generated in the Air, without pretending that they may not come to pass many other ways; for as some of these that are now known to us were hid from the Ancients, so perhaps some may be discover'd by our Posterity, of which we are hitherto ignorant.

SECT.

SECT. XVI, and XVII. *Mists and Fogs produced by many Exhalations, and by the Rarefaction of the Air, shewn experimentally.*

To say something first of *Mists* and *Fogs* : It is plain from what has been said, that unspeakable Numbers of Watry Vapors, and other Exhalations, do mingle themselves with Air, by which they render it Thick and Untransparent or Dark : As first, when they arise in too great a Quantity, and are so closely compressed together, as to fill the Air, and to obstruct a free Passage of Light. In the same manner we see in Chambers, where the Smoak does not go directly up the Chimney, as also by the thick Steems of boiling Water in Kettles, the Air render'd in some manner Untransparent and Foggy : The same happens by the numerous Vapors that arise in the Cold Weather in Winter, and here in *Holland*, upon the Breaking and Opening the Ice.

The second way of producing Fogs and Vapors, is, when the Air is more rarified than usual, and thereupon becoming lighter, is no longer able to balance the more heavy Watry Vapors, and to keep them floating in its own Region. A plain instance thereof we may see in *Tab. XIV. Fig. 5.* by making the Water spring out of the Glass Globe A B, from whence the Air was first exhausted (as has been shewn before on another Account in *Contemplation XVII.*) and then fastening or screwing it on to the Air-Pump at D ; so that the very small quantity of Air that remained in it at S, will appear above the Water N P R ; after which the Pump being exhausted, the Cocks E and K must be open'd ; by which means the Air, which at S, gravitated upon the Water N P, meeting with no Resistance, will drive it down towards the Pump, and

and so the Space A N P, becoming larger, the Air that is in it will be likewise more expanded or rarified. Now, as it does also become lighter thereby, the Watry Vapors in it will sink down, and produce a visible and whitish Fog in the Globe, and many times little Clouds, exactly mimicking those that we see in the open Air. But these Mists and Clouds upon the Re-admission of the Air, Q W R, thro' the Water, and, by the Encrease and Compression of the Air at S, do immediately disappear again, and the said Air at S, as soon recovers its former Transparency; and so *toties quoties*, becomes Foggy and Cloudy when it has an Opportunity of dilating itself, and of forcing the Water out of the Globe, upon exhausting the Air; and again becomes clear and transparent, upon the letting in of fresh Air.

SECT. VIII. *Reflections and Observations upon the same.*

WE have made these Experiments very frequently, and from thence observed; *First*, that these Vapors, when the Air appeared heavy in a Barometer, were not seen at the first Pumping, nor did shew themselves sooner, till after some Expansions of the included Air it became lighter and thinner. *Secondly*, This Experiment did not succeed well when the Water and Air were cool; probably, because there were not Watry Vapors enough mixed with the Air: Wherefore hot Water, in a little Glass Vessel (*Tab. XIV. Fig. 4.*) M N, being placed under the Bell, presently fill'd the Air with the Steams which exhaled from it, but upon the admission of fresh Air, vanished as before.

It was likewise observed at another time, that no Mist appearing in the Glass Globe in cold
Weather

Weather, upon making a Fire in the Room, and the Air in a Thermometer shewing itself warmer, we renewed our Pumping a little while after, and the Fogg became immediatly visible. *Thirdly*, We found likewise, that the Mist which had been thus produced in the Glass, subsided by degrees, and the Glass became clearer, without admitting fresh Air into it; As also, *Fourthly*, That these Mists by letting in fresh Air upon them, and by the Wind which the same produced, being put into Motion, occasion'd an agreeable Representation of the irregular Course of the *Clouds* in the Air in the time of *Storms* and *Tempests*.

I have related this Experiment something the more particularly, because it did not always succeed, and forasmuch it seem'd to give us a great deal of Light into the Nature of *Mists* and *Clouds*.

Now that the Natural Mists, and Fogs, and Clouds are of the same kind with these Artificial ones, seems deducible from hence; that most commonly when the Air loses its Clearness, and becomes more dark and obscure, the Mercury in the Barometers descends, and shews thereby, that the Air is become lighter.

I have likewise often observed with Astonishment, that when the Air appeared clear all above and round about us, in a very short while after, the whole Heavens grew dark and were cover'd over with Clouds. Whether this may be deduced from a sudden thinning of the Air (because we know of no other Reason besides, that in so little a space of time can operate so quick over the whole Face of the Heavens) I leave to others. The Barometer may be compared therewith.

SECT. XIX. *An Experiment to prove, that Mists and Fogs may be produced by Effervescences.*

Thirdly, Another manner by which the Air may be render'd Foggy, will appear by an Experiment made with two little Glasses or Phials containing an Ounce each; one of which being almost filled with the Spirit of *Salt-Petre*, or *Aquafortis*, or else with the Spirit of common *Salt*, and t'other with that of *Sal Armoniac*; put the Mouths of both the Bottles near to each other, and you will find, that the Exhalations of both being mingled in the Air, will produce a visible Smoak or Mist, which, if the Bottles be placed far enough asunder, cannot be observed in either of them.

Now that this way of *Effervescence*, as the *Chymists* call it, is brought about by the reciprocal Action of their Particles in the Air, will be readily allowed by any one that ever saw the Effervescence or Fermentation that is caused by pouring one of these Liquors upon the other.

SECT. XX. *An Experiment proving the like Effect by Precipitations or Separations.*

Fourthly, We learn another way from *Chymistry* of turning clear and transparent Liquors oftentimes into a thick and troubled Matter, by Separation or Precipitation: Thus Sublimate or Vitriol dissolved in Water, and filtrated thro' a Paper, does yield a clear Liquor; but pour into it either Salt of *Tartar* or *Potash*, likewise diluted in Water, both of which are transparent, and you will presently see some Parts of the first Liquor precipitated or separated from the rest, by which means the Liquors will lose their Clearness, and be changed into a dark and thick Substance.

Whether this has also place in some of those that People call *Stinking Fogs*, I shall not enquire any farther here ; this is certain, that those Stenches have often a great affinity with that which we discover in making *Milk of Sulphur*, or the *Golden Sulphur* from Antimony.

To prepare the last, they use to boil in Water the Snails of the *Regulus* of *Antimony*, or (as the Chymists have it) the Sulphur thereof mingled with Salt of *Tartar* in the Fire, and to filtrate the same thro' a Paper, so that there proceeds from it a clear Liquor of a reddish Colour, and without any Smell ; but putting in some drops of Vinegar, a grievous Stench arises from it, and the Liquors become thick and untransparent ; until there subsides from it an Orange Colour and Yellowish Powder, which is the *Golden Powder*, and then both the Liquors become clear again.

I have often thought with my self, whether there were not something like this in the Air, which by way of Precipitation might produce those Stinking Fogs ; *First*, by reason of the likeness of the Scent ; and *Secondly*, because I have oftentimes observ'd, upon the Days succeeding these Fogs, a Reddish or Orange Colour Scum, very like that of the above-mention'd Golden Sulphur, upon Standing Waters ; which before those Fogs happen'd, were not to be found there. But I leave all this to further Enquiries.

SECT. XXI. *Fogs are Clouds.*

AFTER having treated of Foggy and Misty Airs, it does not seem necessary to say any thing more about Clouds ; because it is very credible, that what we call here below Mists and Fogs, when raised up higher in the Air, do compose the Matter of Clouds ; insomuch that a Cloud is no-
thing

thing but an exalted Fog ; now that this is something more than a bare Supposition, appears from Experimental Trials made by many People, who having climbed up high Mountains, met with thick Fogs in their way ; but when they were arrived to the Top, they observed the same floating under them like great and white Clouds. *Varenus* gives us a particular Relation thereof in his *Geography*, *Lib. I. cap. 19. §. 41.*

The same is asserted by that great Examiner of Nature, Mr *Mariotte*, in his Discourse *Du Mouvement des Eaux. p. 19.* That climbing up a Mountain, he found himself at one place in the middle of a Fog, which whilst he was below at the Foot of the same Mountain, appear'd to him like a Cloud.

Another common Experiment may be made, when the Gunners are trying their Cannon, by discharging several Pieces at once : Now every one knows that the Smoak thereof seems to those that are under it like a Mist in the Air ; and so it appeared to me and others that were in the Boat with me, between *Amsterdam* and *Buikslot*, like a black Cloud driving softly on ; especially, after it was carried by a gentle Wind, that did not scatter it, to a good distance from the place where it was discharged, and raised up higher in the Air ; So that likewise seems deducible from hence, that it is not always Watry Vapours, but also other Particles and Exhalations of which the Clouds are composed : Concerning which, as also of the Rains and Dews proceeding from the same, and other Meteors properly belonging to Water, something more subservient to our Design shall be mention'd hereafter in our *Contemplation upon Water.* To proceed.

SECT. XXII. *Wind and its Usefulness, and Convictions from thence.*

AMONG the most common, but not the least wonderful Motions of the Air, *Wind* has the principal place. Now it is known to every one, that the Wind is a flood or a stream of mov'd Air, in-somuch that it wants no farther Proof after so many Experiments, only let us observe here first in general, that it is something, which after a very sublime manner, shews the Power and Goodness of the Great Creator.

They that have ever read of, or tried the dreadful Force of Storms and Tempests, of *Hurricanes* and *Travadoes*, will be sufficiently convinced of the Resistless Power of the Wind. But Custom makes us contemplate this great Wonder without any Emotion. But if there should be still any one so wretched as not to learn his Obligations of Thankfulness to the Great Giver of all Things from these his Works, let him for once suppose with us, that there was no such thing in the World as Wind or Motion of Air, but that it remained in a perpetual Stagnation quite round the Globe, like a Pond or Lake of thin and dead Water. Must he not then own ;

First, In case that what was raised up in the Air should remain in the same place, without being carried elsewhere, or so long at least, till it grew lighter, and so ascended, or heavier, and then descended ; (to say nothing of Cities and Countries, which after Earthquakes might be visited with sad and fatal Distempers, by the Corruption of the Air) that great Trading Towns and Populous Places, where the Smoak of so many Fires of Coal, Turf or Wood, the Vapours of so many stagnating Waters, the Stench of so many impure Places,

Places, and thousands of other kinds of Exhalations proceeding from Men, Beasts, &c. did continually and incessantly fill the Air; and the whole World too, would soon be one universal Church-yard and Burying-place; for all its Inhabitants, were it not that by the help of these Winds so exceeding necessary towards the support of all Living Creatures, fresh Air is continually derived to them from the Hills, and other healthy Places round about them; and the unwholesome and infectious Vapours driven from thence, and dissipated in the vast space of the Skies. And can he that observes all this make himself believe that Winds are merely accidental, and that he owes no Thanks for this great Benefit to him that made the Winds?

Secondly, If this ben't enough to convince an Atheist thereof, yet he certainly knows, that if the Vapours drawn from Water were to fall down in the same place from whence the Sun had raised them up, most of 'em being exhaled from the Sea, would likewise fall down again; and that the dry Land, Fruit-Trees and Plants, would never be able to share in their Moisture. Moreover the Course of Rivers running from Inland Countries and Regions remote from the Sea, into which at last they discharge themselves, would likewise in time be partly or wholly dried up: Insomuch that Dews and Rains and Inundations of Rivers, that render the Earth fruitful, failing altogether, make it at last unfit to feed and keep alive, by its Productions, Men and other Creatures that dwell upon it.

Now this entire Destruction of almost all that breaths upon the Earth, is solely prevented by the Winds: By the Means of which those Watry Vapours, that do mostly arise from the Sea, are carried to dry Places, that they may there descend in Rains, Dews, Snows, and other Meteors; and

supply for the most part the refreshing Streams of Brooks and Rivers with continual new Matter.

Now if so many Men, so many Beasts, so many Birds, so many Fishes, and so many thousands of Trees and Plants, were made without Wisdom and Design : Can any one say, without the Contradiction of his Conscience, that the Winds, for want of which all of them would in a little time perish by the failure of their Sustenance, are thus made accidentally and without any determinate Purpose of our great Preserver ? Would he ever dare to assert the same of so inconsiderable an Instrument as even a Watering-Pot, wherewith we refresh the Plants and Flowers of our Gardens ? And seeing that such a thing was adapted to convey a little Water from some adjacent Well or Brook into a Garden, and there regularly to sprinkle the Parts thereof ; would he dare to maintain, that even such a contemptible Vessel was made without any Design of the Artificer ? But if not, how can he expect to pass for a rational Creature, when he pretends to believe the same of the Winds, those great Aquiducts and Watering-Pots of the whole Earth, and for that reason the Preservers of his own Life, and of all other Creatures ?

Thirdly, Now to say nothing of the Obligations under which those Men lye, that make such great use of the Powers of the Winds to their Advantage and Pleasure both ; so that where there be no Rivers to turn Mills, they can apply these Streams of Air to the same Purpose : Can it be imagined, that the said Winds are produced accidentally, when without their Assistance the Inhabitants of the World could reap no Benefit from any of those Countries that are separated from them by great Seas, nor enjoy any Communication therewith ?

If such Powers of the Wind, by which great and heavy Ships are convey'd so swiftly from one

Part of the World to another; by which such great Machines can be moved as shall suffice, with the Care of a few Men, to drain and keep dry so many Watry Lands, to saw and prepare so much Wood for Building, could be bought or hired with Money; Can any one believe, that besides the Merchants, almost every Body in the World would not be ready to contribute their Share and to pay their Quota, that they might likewise partake of the good Things of other Countries, and of the beneficial Effects of Ships and Mills? Now the most gracious Ruler and Supporter of all Things does hold this so great and so useful a Power as the Wind is in continual Readiness for every Man that will embrace the Advantage of it, even for nothing, and without expecting any other Returns than those of Thankfulness: And all this He vouchsafes to do, that he may display his Wonders even to his Enemies themselves, by a Matter that is invisible; inasmuch, that if one had always liv'd in a place where the use of the Wind was never known, he could hardly be induced by the strongest Arguments to give any credit to such a strange and unconceivable thing.

And can then an Atheist set down, contented, when he not only refuses to acknowledge this Benefit (but even blasphemously denies with his Mouth the great Giver of all those things) which, by the Administration of these Winds, happen to the Advantage of himself and all Mankind? Certainly, if the Winds were produced by no other Causes than mere Chance, operating now this way and then another, such a Man ought to be in a continual Fear, that the Air would become fatal and pestilential, by stagnating and putrifying, and the whole Earth a Wilderness for want of Rain, and he himself and all Living Creatures would perish by Hunger and Thirst: And if the Winds were not bestowed upon

Mankind as a Token of the Mercy of its Creator, might not he himself draw this Consequence, that he could not be able to escape the Power that exerts itself so terribly in the Winds, and at some time or other he would most justly feel the Effects thereof, as a Punishment for these his Blasphemies?

SECT. XXIII. *The Trade Winds and Monsoons.*

IT must indeed be allowed, That if there be any thing in the World that these miserable Philosophers may, with an Appearance of Truth, pretend to be Accidental, it is the Wind, especially after the manner that it moves and blows in these Countries; insomuch, that it even gives a Handle to that Proverb, by which, if one would express in the strongest manner the Inconstancy and Fickleness of another, we say, he is *as Changeable as the Wind*. But to convince them, that even the Winds are far from being governed by a simple and variable Chance; let them enquire into the Experiments of Sea-faring People; and they will see (and if GOD be gracious enough to them, they will likewise be convinced) that the Providence of the great Governour has bound these Winds, which seem to us to come from all Corners of the World with so much Irregularity and Uncertainty, by as fixed and determinate Laws, as ever any Clock or Watch made by its Artificer.

But not to speak any thing more in Confirmation of what we have now said concerning those Land and Sea Winds, which vibrating, like the Pendulum of a Clock, do every four and twenty Hours blow backwards and forwards upon certain Coasts, without which many Countries would not be able to subsist, nor many Voyages be made safely and conveniently; there are besides the changeable Winds
that

that govern in our, and other Parts of the World, two principal and well known Kinds of regular Winds: One of which does the whole Year round observe in a manner one and the same Course, always blowing from the same Quarter, without any Observation of any Return, or of any contrary Wind; and these are named by Mariners and Geographers, *Passage* or *Trade Winds*. Those of the Second Sort are such as they call by the Name of *Monsoons* or *Mousoons* (in Latin *Motiones*) and these blow one half Year from one Corner, and then another half Year from that Quarter of the Heavens directly opposite.

Without these Trade-Winds, how could they sail upon the great Ocean? How could there hardly any Ship arrive at the *East-Indies*? Since at some Degrees North of the Equinoctial it meets with a South-East or Trade-Wind, which, being in a manner directly contrary, does perpetually reign there; and as near as a Ship can sail against or bear up to the Wind, as they term it, drives it upon the Coast of *America* and to the *Abrolhos*; and whereas they endeavour to steer their Coast Eastward, they are obliged to make away so far to the West, that they may get out of the Reach of these Trade-Winds. Being come so far, they are brought by changeable Winds to the *Cape of Good-Hope*: From whence, sailing into the 38th, 39th, and 40th Degree of Southern Latitude, they meet with another Trade-Wind, which blowing almost contrary to the former, and to the Northward of the West (for which reason it is called the Westerly Trade-Wind) carries the Ship to the Journeys End; and that too with so great a Force sometimes, that according to the Observations which a very curious Mariner communicated to me out of his Journal, his Ship was driven by this Wind above 50 Leagues to the Eastward

ward in the space of 24 Hours. And when the Ships return from the *East-Indies*, the first South-East Trade-Wind is again serviceable to them to carry them some Degrees North of the Line.

SECT. XXIV. *Convictions from the foregoing Observations.*

I HAVE often consider'd with myself the great Advantages that accrue to the *Dutch* from their Travelling in *Trek-Schuits*, or Boats drawn with one or more Horses; by which they can in a manner, throughout the whole Country, compute exactly the Time required to pass from one Place to another, let the Distance be what it will.

Will now any Atheist, how obdurate so ever he may be, dare to maintain, that those who alone enjoy the Conveniency thereof, are not the least obliged to the Prudence and Foresight of their Governours for it; who have been pleased to appoint the same for the Publick Good, in order to render the Correspondence of one City with another the most Cheap and Convenient to the Inhabitants? And that those have most Truth on their Side, who affirm, that it is by mere Chance, or at least, without any View or Design, that at every time, and as often as it is required, fresh Horses are at hand to draw the said Boats?

Now if we were to use no other Arguments; might not this Constancy in such uncertain and variable Motions as are those of the Winds, convince every reasonable Person, that the Creator and Ruler of all Things, has thereby proposed to himself certain principal Ends and Purposes? For if variable Winds and Calms should indifferently reign in all Parts of the Ocean, what Computation could be made of bringing a Voyage to any sort of Conclusion? And how many unhappy Seamen being de-

detained in these long Voyages by Calms or contrary Winds, would run the Risk of perishing with Hunger and Thirst.

For a Proof hereof, we shall make use of the Words of that great Mathematician, the present learned Professor of Geometry at Oxford, Dr. Edmund Halley, who, after he had been a long time between the Tropicks upon the Island of *St. Helena*, and having made diligent Enquiry into the Nature of the Winds by all possible Means, informs us (as we find it in the *Act. Lips.* 1687. p. 512.) that about the Coast of *Guinea* he observed many Calms and Tornado's, which are terrible Winds, that run round the whole Compass; and then he proceeds, Sect. 7. that between the fourth and tenth Degree of Northern Latitude, between Cape Verde and the Eastern Islands of the same Name, there is a great Extent of the Sea, of which it might be said, there did not blow any, not even variable Winds at all; and that the Sea seemed to be condemned to a perpetual Calm, and was attended with dreadful Claps of Thunder and Flashes of Lightning, and great Storms of Rain. The Winds that are there did only deserve the Name of little uncertain Blasts, shifting hourly, and before they shifted becoming Calm; so that several Ships before they could make 6 Degrees, or about 120 Leagues, were obliged to spend whole Months (*Varenus*, in his Geography, Lib. I. cap. 21. §. 16. says three at least) for want of a Wind.

They that would be further informed of the Properties of these Winds, may meet with a great many Observations and Discourses concerning them in the Works of the Learned *Verulamius*, *Varenus*, *Mariotte*, and the so called Sea-Charts or *Atlas*; particularly all that relates to Trade Winds, and Monsoons is very accurately described by the said Ingenious Dr. Halley, and may be found in the abovemention'd *Act. Lips.* for the Year 1687.

SECT. XXV. *A Brief Description of the said Winds.*

To form a general Notion of the same ; let any one place before himself a Globe or Map of the World, and view that Zone that is contained between the Tropicks on each side of the Equinoctial, as Dr. *Halley* has represented it ; They call it the *Torrid Zone*, by reason of the Heat. Here he will see, that the Waters of the Great and General Ocean may be consider'd as divided into three Parts, by the Intervention of Lands : The first is the *Ethiopic* and *Atlantic Sea*, between *Africa* and *America* ; to the Eastward there lies the Second or *Indian-Sea*, between *Africa*, the *Indian Islands*, and *New-Holland* ; the Third is the great *South-Sea*, or *Mare Pacificum*, extending itself from the *Western Coasts* of *America* along the other side of the Globe quite to the *Philippine-Islands*.

Now according to the Observations of Dr. *Halley*, and others, we find :

I. That between the Tropicks in the *Atlantic* and *Ethiopic*, as also throughout the whole *South-Sea*, there always reigns an Easterly Trade-Wind, which South of the *Equator* is something Southerly, and North thereof somewhat Northerly.

II. That these Trade-Winds do not reach farther than to about 30 Degrees on both sides of the *Equator*.

III. That however there continually blows a South-west Wind about the Coast of *Guinea* upon the Land.

IV. That in the Southern Part of the *Indian-Sea*, the Wind blows always from the East or thereabouts, with as much Certainty as in other Seas. So that a constant Easterly Trade-Wind, and which

which surrounds the Globe, is found at all times in the Places before-mention'd.

V. But it is very wonderful, that on the North-side of this said *Indian-Sea*, the Winds which do one half of the Year blow continually from the East, as in other Seas, turn again the following half Year, and blow directly contrary from the Western Parts of the Heavens; and these are called the *Monsoons*. As for the other Particulars of those Winds, mention'd in the aforesaid Quotations, we shall pass them by.

SECT. XXVI. *Transition to Experiments about the possible Causes of the Winds.*

It will not then be necessary for us to make a great shew, as some do, of the Knowledge we have either acquired our selves concerning these Winds, or have learned from other People: But it seems best to adore the Great Director in his unscrutable Ways and Works, as despairing ever to attain to Perfection herein. However, since there appears a great many things to be sufficiently known concerning the said Winds (tho' it be very little in it self, with respect to the Importance of the Matter) to prove from thence the Wisdom and Power of the Creator; that we may not pass by all of them untouched, but furnish some Opportunity to such as have any Inclination to make further Enquiries therein, we shall briefly propose a few Experiments, which have been, and perhaps may still be useful to many, either for a Foundation, or at least some Direction in their Thoughts and Discourses about them.

SECT. XXVII. *The first Experiment touching the Contraction of the Space in which the Air is contained.*

SINCE the Essence of the Winds consists in a Motion or Protrusion of the Air from one place to another, it is certain, that whatever is capable to protrude the Air after such a manner, is likewise proper to cause a Wind. Accordingly we find ;

I. That the Air may produce a Stream and a Wind when it is shut up any where, and the Place containing it is render'd narrower; whereupon being pressed, it forces its way thro' all the Passages it meets with, and thereby represents a Blast or Wind.

This we may see when a Man blows with his Mouth, or presses a pair of Bellows, or in the sudden fall of things that have any breadth in them, whereby they press the Air between them and the Ground, and driving it away on every side, produce a sort of a Wind. This way of Generating a Wind was known to *Hero Alexandrinus* many Ages past, by making of a hollow Vessel that was Air-tight, and had two Tubes, a great and a little one : Thro' the greater there runs Water with some Swiftness into the Vessel or Cistern, which ascending in the same, contracts the Space wherein the Air was contained, and so forces the said Air with a Blast thro' the narrow Tube, by which means they cause little Flutes, Pipes of Organs, and Figures of Birds to yield a Sound; to say nothing of blowing Fires, and even Smelting Metals in some Places after the like manner.

SECT. XXVIII. *The Second Experiment with a hollow Globe or Æolipile.*

II. SOME Philosophers (upon observing the Experiments of heating a hollow Brass Globe, having a little Orifice or Hole in it, and then throwing it into cold Water, to cause the Water to go into it, and afterwards making it hot again over a Fire, whereby the Vapours rush out like a violent Wind) have thought that the Wind does not so much consist in a Motion or Protrusion of the Air as in Watry-Vapours, which this Experiment of an *Æolipile* or *Wind-Globe* confirms; and have therefore endeavour'd to deduce all the Properties of the Wind for the most part from such Experiments. But we shall not here enquire either into the Probability or Difficulties of their Hypothesis. [See the Figure of such an *Æolipile*, *Tab. XXII. Fig. 3.*]

SECT. XXIX. *The Third Experiment. The moving of Solid Bodies through the Air.*

III. ANOTHER manner of moving, or producing a Stream of Air, is by causing a Body to pass swiftly thro' it; forasmuch as by that means the Air follows the said Body with a great Velocity, and raises a Wind behind it.

To make a very easie Trial thereof, one need only extend ones Hand, the Fingers being closed, and swiftly strike upon the Air from one side to the other; whereby one shall be aware that the following Air sensibly blows against the opening of the Hand, especially if you moisten the same with a little Water, for then you will more sensibly feel the same.

But to give a visible Proof thereof, drop some little round Bullets from any due Heighth into a
Bucket

Bucket of Water ; and as soon as they fall to the Bottom, you will see some Bubbles of the Air that followed 'em rising up from the Bottom to the Top of the Water ; insomuch, that many times if the Bullets descend from a greater Height, and consequently with more Swiftness, the Bubbles will even be as large as the Bullets.

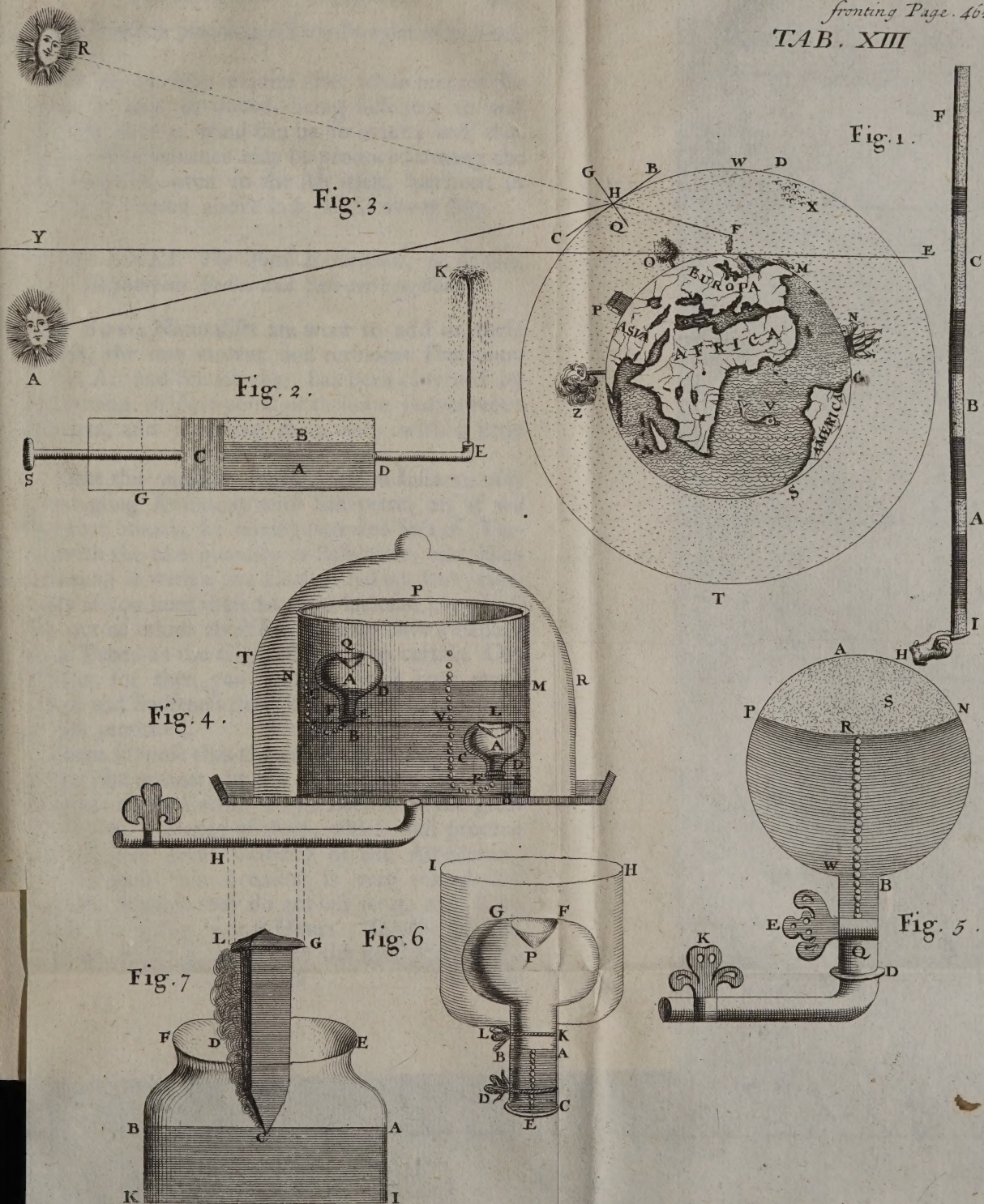
The same has been observ'd in the Force of the Wind, which some have felt to their Harm, upon a Cannon-Ball's passing very near them, yet without touching them.

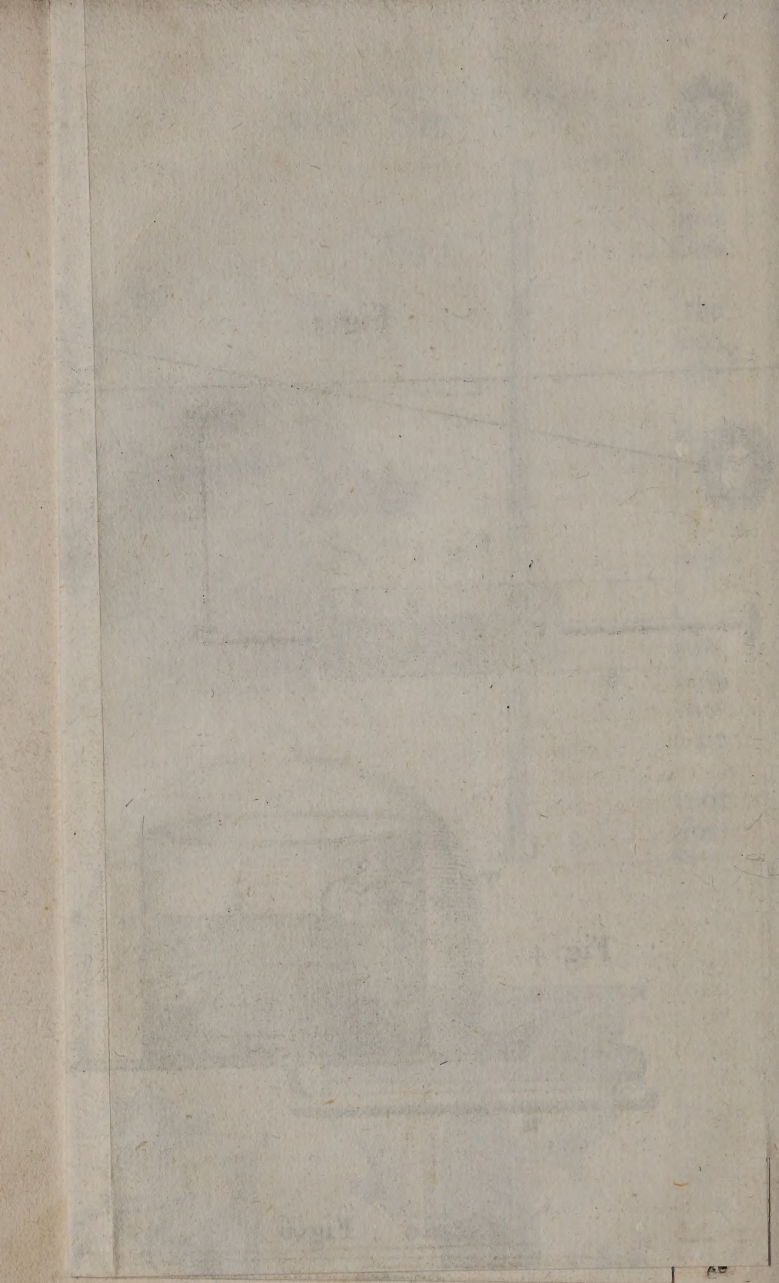
'Tis the like Sort of Wind, as some think, that is excited by the rushing of great Hail-stones, as they swiftly descend.

SECT. XXX. *The Fourth Experiment ; Effervescences.*

IV. WE see a Wind likewise generated by mixing together two Effervescent Matters, and causing them to ferment ; and it is the same thing, whether both of them be Liquid, or one of them be a Solid Body.

Accordingly, if you throw Filings of Iron or Steel into Spirits of Salt-petre, or into Aquafortis ; or mix with the Spirit of Sulphur, Sea-Salt, Copperas, or any other Acid Spirit, an Alkaline Liquor, such as Spirit of Sal-Armoniac impregnated with Potash, or Spirit of Hartshorn, Salt of Tartar, or Potash itself dissolved in Water, they will produce a Fermentation with great Violence, and exhale a Stream of Air and Vapours out of the Mouth of the Glass or Vessel that you put them in ; of the Force of which Fermentation or Ebullition you will be the more sensible, if you stop the Mouth of the Glass for a little space, whilst they are working together ; but you must not keep it shut too long, for unless the Glass be very strong,





it will burst in pieces as if Gun-Powder were kindled in it.

We do not here enquire after what manner the Wind is thus produced, being sufficient to our Purpose, that a Wind can be so made; and that such an Effervescence may be produced among the like Particles, even in the Air itself, has been in some sort proved above in §. XIX. about *Fogs*.

SECT. XXXI. *The Fifth Experiment, by burning Sulphureous Bodies and Salt-petre together.*

V. SOME Naturalists are wont to add to these Winds, the very violent and turbulent Protrusion of the Air and Smoak that has been observed by the mixing of Salt-petre with some Sulphureous Matters, and touching them only with a little Fire.

After this manner, we shall see an Instance of it in mingling Antimony with Salt-petre, or, if we fear that Smoak, by mixing pounded Salt of Tartar with the like quantity of Salt-petre, and then inflaming it with a live Coal, or red hot Iron, especially if you burn these Matters inclosed in a Vessel, out of which their Smoak may have a Passage by a Tube, as the Chymists do upon certain Occasions, for then you will see with how much Force and Swiftnes there is a Wind and Stream of Air produced.

Some suppose that the *Hurricanes* are generated in the like manner, by the inflaming of some such Matters in the Earth. *First*, Because of the great Force and Violence of them, which must proceed from a very great Velocity of the Air-Stream, which upon this occasion is very remarkable. *Secondly*, Because they do not last long, and commonly not above 7 or 8 Hours. *Thirdly*, Because they are observ'd to rule for the most Part in cer-

rain Places only. *Fourthly*, Because (as we see in the aforesaid Burning Matters) the Streams of Smoak diffuse themselves on all sides, and so the Wind blows from all the Points of the Compass. *Fifthly*, Because Earthquakes are often felt at the same time in the adjacent Places, and Dead Fishes found floating in those Parts of the Sea that are nearest.

Now, that these Fires produced by Salt-petre and Sulphur, tho' kindled under the bottom of the Sea, are not extinguished by its Waters; and that the Smoak thereof forces its way upwards thro' the same, may be easily accounted for by the Fire-works, that perform their Operations even in the Water, where they will remain a great while, without being extinguished, and from whence Men may see the Smoak of them ascend. The same thing will appear as plainly, by kindling a little Squib or Serpent, as they call it, and throwing it into a Glass full of Water, where you will perfectly see the Squib burning out, and all the Smoak of it rising thro' the Water, insomuch, that if any Fish were there, 'tis probable they would all dye.

Whether this be the true or only the probable Cause of those dreadful Winds, which they call Hurricanes, we shall not enquire any farther here.

SECT. XXXII. *The Sixth Experiment, shewing, that the Elastick Power of the Air being augmented, produces Winds.*

BESIDES the foremention'd Causes of the Production of Winds, the Great and Principal Property of the Air does still furnish us with another; which, tho' unknown, 'till of late Years, is yet esteem'd by many, and with great Appearance of Truth, in this Age, for one of the Causes of Winds. This has been shewn before in the particular Account which we have given of the *Elastick Power* of

of the Air; by which it continually endeavouring to dilate itself towards every Part where it does not meet with a sufficient Resistance, breaks forth with a great and swift Stream; insomuch, that when we take away the Balance of Force, by rendering one of the two adjacent Airs stronger, or t'other weaker, the strongest always expands itself towards the weakest, and by protruding or driving it forwards, causes that Motion which we call Wind.

VI. The Particles of the Air press upon one another in a Wind-Gun; by which means their Elasticity is augmented; and we may see that it will drive out a Bullet, notwithstanding the Resistance of the usual and external Air, with such Velocity as is now well known to the Amazement of many.

After the same manner, if you blow Air strongly into a little Bottle with a narrow Mouth, and give it room to flow back again, you will find that it will rush out from thence with great Swiftness, tho' it was a long time in blowing in, only because it is strongly compressed within that narrow Space. Now whether certain Sorts of very violent Winds do suddenly exert themselves like Gusts and Blasts, after the same manner, because two other more gentle Winds driving before them all the Vapours and Clouds in the Air, and blowing them against each other, do compress the interjacent Air, and dispose it so as to break out with a great Swiftness, for want of a sufficient Resistance, we shall leave the further Enquiry to such as think it worth their while, and may meet with Opportunities of making it.

SECT. XXXIII. *The Seventh Experiment ; the Diminution or Weakning of the Air will produce the same Effect.*

VII. Now, as we have shewn from hence with how great a Velocity the Air can be protruded as it becomes stronger in its Elastick Faculty, it being thicker and closer compressed in the same Place ; the same Velocity does likewise exert itself when the Balance of the Resisting Air only is taken away either in whole or in part, by diminishing the Quantity thereof in any Place.

Thus we see when a Vacuum is made by exhausting the Air, the common Strength of the external Air forces in with very great Swiftmess. Several Experiments proving such a strong Blast, have been already quoted upon the Subject of Respiration.

Those who desire to see more Proofs may consult the Machines of Messieurs *Guerike* and *Papin* (*Act. Lips. Anno 1686. p. 500.*) with which, in the presence of the *Royal Society of London*, the same Force and Noise was in a manner produced by the rushing of the Air into a Vacuum, as is usually made by the compressed Air in a Gun, being let out.

However, if those that have neither an Air-Pump, nor such Machines as these at hand, are desirous to make this Experiment, namely, that the Air forces itself like a violent Wind into a Place where the internal Air is either much diminished, or has very little Elasticity in it : Let them take a Glass Bottle, first putting a little Water into it, and tying a wet Bladder over the Mouth of it ; so that turning it upside down, there may be about the Quantity of two Fingers breadth of Water in the Neck of it ; then turning the Bottle right again, that the Water may descend to the Bottom of it, and the Neck remain empty ; Let them make a little Hole in
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the middle of the Bladder, with a Pin or Needle, and thro' the same suck out the Air from the Glass, as strongly as they can for several times; stopping the Hole at every turn with the Finger, that no Air may get in again.

When this is done as well as it can be; let the Bottle be inverted again, so that the Water may run into the Neck, and upon the Bladder stop'd with the Finger; upon the removing of which Finger, the External Air, like a Wind, will rush into the Bottle thro' the Hole of the Bladder and the Water lying upon it, and rise up to the Top, where the Internal Air had been diminished and weaken'd by Suction.

Now, if according to the Calculation of the Mathematicians, the Air, which forces itself into a Vacuum, moves with so much Velocity, as to advance 1305 Foot in a Pulse or Second of a Minute (*see the Act. Lips. Anno 1688. p 158.*) and according to the Observation of the accurate Mr. Mariotte, it being very difficult to withstand, or advance against a Wind that moves 24 Foot in a Second; and that another, that runs 32 Foot in the same time, produces such a Storm, as is capable of tearing up Trees and overturning Houses: (*See his Discourse du Movement des Eaux, p. 67, and 78. See likewise the said Treatise lately done into English, by the Ingenious Mr. Desaguliers*) What Havock and Destruction of every thing might we not expect from the terrible Force of such a Wind, which being above 40 times as swift, would therefore, supposing the moved Bodies to be the same, exert 40 times as much Strength as the aforementioned Storm; especially, if that Air which surrounds the whole Globe should have the Opportunity of displaying its Elastic Power upon any great Space that were almost or altogether empty of Air? Now, whether such

a thing may be supposed to have ever happen'd ; and whether Winds have been protruded after the like manner in the open Air, we shall not here enquire.

But this however may be plainly infer'd from what has been said, that the Pressure of the Air being enabled to exert itself with its utmost Force, would, by its exceeding Swiftneſs, produce moſt dreadful Effects; deſtroying every thing upon the Face of the Earth, in a very little Space of Time, as has been already ſhewn in *Contemplation XVII.* by an Experiment of the Air's Breaking a Glaſs, tho' the ſame was far from being exhausted of all its Air.

SECT. XXXIV. *The Eighth Experiment ; Of producing Wind by Cold.*

VIII. WE have ſeen that the above-mention'd Motion of the Air or Wind was produced, by diminiſhing the Quantity or Strength of the Air. But beſides this, there is another Caſe in which, tho' the Quantity of the Air be not diminiſhed, yet the Elaſtick Faculty thereof is weaken'd ; namely, when one Air is only colder than another, which in every thing beſides may be like to the Firſt : By which means alſo a Wind is generated when the leſs Cold, and therefore ſtronger Air expands itſelf, and preſſes upon the more cold and conſequently weaker Air.

Many Experiments proving the ſame, are well known to the Naturaliſts ; and the Operation of the Thermometers, which are moved by Rarefaction and Condensation of Air, do frequently ſhew the ſame.

But to give a very eaſie Proof hereof, you may try the following Experiment : Bind a wet Bladder upon the Mouth C D, of a Glaſs Bottle F G C D, (*Tab. XIV. Fig. 6.*) after having pour'd ſo much

Water

Water into it, as will not quite fill the Neck K C, when the Bottle is inverted. Then take a Second Bladder H K L I, cutting off the Neck of it in such a manner, that the Orifice H I, may be very large; then having made a Hole in it at K L, the Neck K L C D, will thereby go thro', and the Bladder at K L must be tied or twisted very close about it. After which, throwing in a handful of Salt, and one or two handful of Snow into the Bladder H I K L, upon the globular Part of the Bottle F G K L, stir the same together with a Stick or Spoon; when, as it is will known, the Snow will begin to melt, and the Air in the Bottle, which is encompassed with this Mixture, will become very cold; and the Water itself, if it were higher in the Neck of the Bottle than K L, would easily be Frozen, which might embarrass the Experiment, and for that reason, the Water ought not to be higher than A B, or below the Bladder K L. Now that the Air in the globular Part of the Bottle F G K I, is weaken'd in its Elastick Faculty by this Cold; and that the less cold External Air, being enabled to act upon it, will expand itself with greater Force, and produce a Wind, blowing upon the colder and weaker Air at P, may appear by pricking the Bladder C D, with a great Pin at E; whereupon one may see the Air forced through the Water A B C D, that is in the Neck of the Bottle with a remarkable Velocity, like a Wind up to the Globular Part F G K L.

This Experiment having been likewise tried in the great Frost upon the 12th of January, 1709; 'twas observ'd, that as cold as the Air was then, yet by this Mixture, and by the greater Cold, it lost still more of its Elastick Power; and the External Air being stronger, rushing like a Wind thitherwards, shewed that a great Quantity of Air may be squeez'd together in a cold Place. That which

might probably be infer'd from this Operation of the Cold upon the Air, concerning Winds, shall be treated of in some manner hereafter.

SECT. XXXV. *The Ninth Experiment ; Of Wind produced by Warmth.*

IX. THE Operation of Warmth is directly contrary to the foregoing, dilating the Air with greater Force, thereby producing a Current of Wind towards all these Places, where it meets with no Resistance.

This might likewise be shewn by the Thermometers, in which the Warmth expands the Air ; but to represent it to those that have no Thermometers at hand ; Set again a Bottle, in which there is nothing but Air, with the Mouth turned downwards upon a Plate or Dish, upon which you must pour as much Water as may rise just above the Brim of the Mouth of the said Bottle, and thereby prevent any Communication between the External and Internal Air. Now if you hold a Burning-Coal, and move it round the Globular Part of the Glass upwards and downwards, so as to warm the Air within it, you will see that the rarified Air rushing out in little Bubbles between the Bottle and the Plate, will produce a soft and gentle Wind.

If you have a mind to see this Experiment confirmed with a stronger Blast, you must apply a more sudden and violent Heat thereto ; as may be easily done, if you make use of a Bottle encompassed with a Bladder (*Tab. XIV. Fig. 6.*) and leaving it open at CD, set it down upon a Plate, with Water, then pour hot Water upon the bottom of the Bottle FG, and all round it, with some Care least it burst ; this increased Heat will produce a swifter Current of Air or Wind, made by the Air, which rushes out as it is expanded.

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SECT. XXXVI. *The Tenth Experiment ; Wind produced by the Suspension or Cessation of Warmth.*

X. BUT forasmuch as by the driving out of the Air by Warmth, the same is diminished in the Bottle, and therefore, when the Warmth that had driven it out ceases, the Expansive Faculty will become weaker than it was before, whilst there was a greater quantity of Air in the Glass, and whilst it had a Communication with the surrounding Air. It will therefore follow, that the External Air having the same degree of Cold or Heat with that which was included in the Bottle, and being diminished in its Quantity by the foregoing Warmth, will pass more strongly that way, and so croud itself into the Bottle with a returning Wind. One that understands Hydrostaticks, might demonstrate the same in the preceeding Experiments ; forasmuch as the Air within the Bottle losing its greater Heat, the Water will rise up into the Neck of the said Bottle from the Plate, by the Pressure of the External Air: But as this is writ for the sake of the Ignorant, to make them even see the aforesaid returning Wind, put into a Bottle again as much Water as will fill the Neck when it is inverted, thereby to render visible, as above, the Discharge of the said Wind thro' the Water ; then hold the Bottle for a while over the Steams of boiling Water, to the end, that the sudden Heat may not burst it, and finally put it into the boiling Water itself, till it be very hot, and the Air rushes out by the Mouth of it, which is open, as is done above in §. XXV ; then take a warm wet Bladder, and tie it as close as you can upon the Mouth of the Bottle, and invert it so, that the included Water may lie upon the Bladder ; then set it by for a little while in the same posture, till the

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Internal Air lose its Warmth, and become equally cold with the External. Now if the Bladder be tied close enough, the Expansive Power of the Air, which is in the Bottle above the Water, will become weaker than that of the External, because the quantity of the Air is diminished, and is therefore more rarified: Wherefore in case the External Air, which is strongest, can operate against the other, it will be driven with a Current or Stream against the rarified Air; which may be discover'd by making a Hole in the Bladder with a Pin, whereupon you will immediately see the External Air, like a Wind, rising up thro' the Water.

Now, whether from all these Properties of the Air, and from the Heat of the Sun operating thereupon, the Easterly Trade-Winds, and in some measure likewise, those that blow from the South in Spring and Summer, and from the North in Autumn and Winter, may be truly prov'd according to the manner of the Modern Naturalists: Those that are curious, may enquire by consulting them.

SECT. XXXVII. *The Eleventh Experiment; Wind produced by the Motion of the Air upwards.*

XI. THERE is still one other Motion and Current of the Air mention'd by Dr. Halley, in his Discourses about the Winds (*see Act. Lips. Anno 1687.*) by which it acquires a Process upwards; namely, when the Air, being rarified by Warmth or otherwise, grows thinner, and consequently lighter in the same place, than when it is compressed and encreased by Cold (as it has been shewn upon other Occasions;) it follows therefore, that in case the Warmth descends perpendicularly from the Sun, there will be produced directly under it, a freight ascending Column in the Air, as far

as the great and descending Heat extends itself; in which Column the Air will be much lighter than that which is about it, and which has not so much Heat. Now if we look upon this thinner Air as Oil, and the surrounding colder Air as Water, every Body must own, that as a Column of Oil placed in the middle of Water does emerge, is driven upwards, and, according to the Laws of Gravity, diffuses itself upon the Surface of the Water, the same Appearances will likewise happen in this rarified Air. Dr. *Halley* uses this Comparison, to give us some kind of Notion, tho', as he owns himself, a very imperfect one of the Motion of the Air in the *Monsoons*.

In order to support these Arguments by Experiments, and to render in some manner visible such a Current and Wind produced in the Air, take a little Glass, E F K L, (*Tab. XIV. Fig. 7.*) about six Fingers high, and the Mouth of it between two or three Fingers broad; set it upon a Table, then take a lighted Pipe of Tobacco, and put the Bowl of it in your Mouth, cloathing it with Paper, if it be too hot, and support the little End of it at I or K, upon the Bottom of the Glass, and blow the Smoak of it as hard as you can into the Glass, till it comes very thick out of the Orifice E F, and filling the Glass, renders it quite dark or untransparent, which it will do very soon; then take the Pipe out of it, staying till the Smoak in the Glass has in some measure lost the chiefest Part of its Motion, and stands still like a stagnating or gently moving Water, and represents a kind of a Superficies above at A B; then take a Nail G C, about a large handful in Length, and hold it with a Pair of Tongs by the Point C, or a little higher, (having first made it red hot for that Purpose) and place it in a direct perpendicular Posture, as at G C; then beginning, as at H, let the hot Point of the said perpendicular Nail gently descend from
H to

H to C; and you will see as soon as the same is come from H to C, or to the Superficies of the Smoak A B, the said Air and Smoak creeping along the Nail, and ascending in a direct Stream from C to L; which especially from C to D, or so far as it remains below the Brim of the Mouth of the Glass, will preserve its Streightness; and sometimes, even as high as at L, when the Air in the Room is very still, which otherwise is wont to scatter and disperse this Column of Smoak as soon as it rises above the Brim of the Glass. To all which Circumstances, as minute as they are, you must carefully attend, if you would make the Experiment with its requisite Niceness. Now what has been said before is made good by this Experiment.

SECT. XXXVIII. *Convictions from what has been represented about the Air in general.*

Now will any Body deny, that the Wisdom of our great Creator does in all these things far surpass the Thoughts of Men; who for so many Ages has been pleased to make use of such various Methods, and perhaps of many more too, to turn the Air into Winds; tho' it is very certain, that the Knowledge of most of these kinds of Winds, yea, of all that owe their Origin to the Gravity and Elasticity of the Air, and perhaps too of such as are produced by Heat and Cold, has been concealed till lately from the whole World; and who can tell, but that those that are still hidden, may be reserved for the Discovery of our Posterity?

At least, a generous Philosopher may learn from hence to entertain very humble Sentiments of his own Knowledge, and to see the Fallacy and Sophistry of those *strong Minds*, who fancy they can fathom every thing. *First*, Because we have
seen

seen so many and so famous Naturalists in those Times, treating with so much Certainty, and even with the Approbation of very Learned Men, about the Winds ; who, if the Experiments of following Years, touching the Motions of the Air, had been known to them, would have even been ashamed of the Conceit of their own Skill therein. *Secondly*, Because, as has been just now hinted, even in these our Times, in which the Grounds of the Knowledge of the Winds have been so much augmented by new Experiments, the greatest Mathematicians and Enquirers into Nature, that speak sincerely, have openly confess'd how far they still are from attaining to a true Notion of these things.

But if an unhappy Atheist cannot be yet brought by these Representations of the Greatness of God, and of his own Meanness, to confess the Power of his Adorable Creator ; let him (if this may in any wise contribute to set him right) I say, let him with us contemplate the Globe of the Earth ZFG (*Tab. XIV. Fig. 3.*) and observe, that there are found upon the same so many humane Creatures at F, so many Beasts at M, so many Fishes at V, so many Birds at X, so many Trees and other Plants at O, so many stately Palaces and other Buildings in Cities and Towns at P, so many Fires for the Use and Service of Mankind at Z, so many Ships at N, which may pass from one end of the World M, quite to the other G : And to say no more, let him seriously consider all the Wisdom and Art wherewith each of these things have been made after so wonderful a manner : Further, let him suppose all those Men and Beasts to be without any Life or Motion ; the Fishes divested of the Power of Swimming, the Birds of Flying, the Fire of Burning, the Trees and Plants of Growing ; let him fancy all the Towns to be uninhabited, and all Communication between the most remote Coun-

Countries interrupted for want of Shipping; Will not the whole Globe of the Earth, with every thing that is upon it, appear to him a most Melancholy and most Frightful Wilderness? But now if any one should come and tell him, and convince him too by ocular Demonstration, that it was possible to endow a certain fluid and invisible Matter surrounding this Globe with such wonderful Qualities, that by means of the same, so many Millions of Men, and other Creatures could live; that the Fishes which he now sees floating upon the Water, could subsist under them; that the Birds could fly, the Trees and Plants could grow for the support of such Creatures, that Fire could burn for the Preparation of Food, for Light, and a thousand other Uses; that Ships, tho' loaded with a most surprising Weight and Burden, could be carried to the remotest Parts of the World, by the strength of the said invisible Matter; not to recount all the other Services that are render'd thereby to those who inhabit this Globe, would he not, after having seriously weighed all these things, confess the Discoverer or Inventor thereof to be wonderful Wise? Or, could he imagine that this Matter, destined to so many different and important Purposes, was capable of acquiring by Chance, and without Wisdom, the Properties necessary to produce only so many and such great Things, and to range and diffuse itself, of its own accord, quite round the World?

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CONTEMPLATION XIX.

Of WATER.

SECT. I. *Without Water every thing would dye with Thirst.*

NOW let the Philosopher that pretends still to doubt of all these most important Truths, pass on with us to the *Contemplation* of WATER; and without using any farther Preamble, we may venture to say, that he will at least agree with us, without supporting this Truth by many Experiments, that in case there had been no such thing as Water in the World, he, and all Mankind, and most of the other Living Creatures, even in the midst of a Superfluity of Air, and other Food, would certainly perish in a very small compass of time; since Thirst, if it be not extinguished, is no less fatal than Hunger itself, and all Men and Beasts too, a few of the last only excepted, if there be any Truth in Experiments, are unable to subsist without Drink.

SECT. II. *Convictions from thence.*

THIS being laid down, if it be by Chance that Water is found out, which itself is the only Drink, or at least the principal Ingredient of all other Drinks; it is likewise unquestionably by the same Chance that a Man, or any other Animal, lives a Year, or a much less time, after his Birth. And since

since the most obdurate Atheist must acknowledge, that all Living Creatures whatever, are of such Structure, and have the Parts of their Bodies so disposed, in relation to Water, that they are able to take and use it themselves ; that they are even excited thereto by Thirst when they want it ; that they can only be refreshed by Water, whether they drink it Pure, or whether they make use of other Liquors, such as Wine, Beer, Cyder, and the like, of all which, it is the Foundation ; and that therefore, it would not suffice them, if they had the use of all other Liquid Matters : Insomuch, that if the whole Sea, and all Rivers, were made of Spirits entirely separated from their Water, or of other Liquors, in which there were not a sufficient mixture of Water, they would still all perish of Thirst. Can it then be thought, that it is owing to mere Chance, that all Creatures have the Faculty of supporting their Lives by Water, and likewise that Water has by the same Chance acquired the Properties that are necessary for that Purpose ?

SECT. III. *Without Water every living Creature would likewise dye of Hunger.*

TO this we may likewise add, that without Water the Earth would not be render'd Fruitful, nor any Tree or Plant would be able to spring out of it; so that the Condition of the World would be still very miserable, if all the Men and other Creatures in it, could subsist without Water ; since every living thing would soon be deprived of its Meat as well as Drink; the Consequence of which would be certain Death.

SECT. IV. *Experiments proving that Plants consist for the most part of nothing but Water.*

LET no Body imagine, that we go too far in extolling the Uses of Water: That famous Experiment of *Van Helmont* does plainly shew how much Water contributes to the growth of every thing. He took two hundred Pound Weight of Earth, first drying it thoroughly in an Oven, and then pouring Rain Water upon it, and having planted in it the twig of a Willow, that weighed five Pounds, he found at the end of five Years, that the said Twig was grown to a Tree, weighing 169 Pounds three Ounces, without counting all the Leaves that had fallen in four Autumns; but that the said Earth being dried again as before, was scarce visibly diminished, or at most, had not lost above two Ounces of its Substance. And yet nothing more was done to it, than pouring upon it Distilled or Rain Water, for which reason likewise, the Pot was cover'd with a thin Plate full of Holes, to prevent, as far as possible, either the Encrease or Diminution of the Earth by Winds, &c.

The like Experiments may be seen in Mr. *Boyle's Sceptical Chymist*, Part II. where without any Diminution of Earth in one Year, at least without any that was worth speaking of, you will read of a Pumkin of a very great Weight, which was produced only with Spring or Rain Water.

The same Author does likewise mention other Experiments made upon little Plants of *Mint*, *Sweet-Majoran*, *Purslin*, &c. which I have often repeated with Pleasure and Wonder, by putting them into little Glass Phials, where I could observe them spreading out their Roots, putting forth their Leaves, and becoming Larger and Longer: The said Mr. *Boyle* says, that having distilled them in

a little Retort, tho' they were produced by nothing but Water, yet like other Plants of the same kind, that spring from the Earth, they yielded a little Water, a stinking Spirit, and an Oil, the Remainder being nothing but a *Caput Mortuum*, or Dead Coal.

How many Trees grow in Norway (as Travelers that have been there relate) in Places where there is very little Earth, and hardly any thing besides barren Rocks? Whence comes all that Wood (which no Body will easily ascribe to the Rocks themselves) but from the Rain Water with which they are moisten'd? A like Instance occurs to me whilst I am writing this, of Elder Tree, which sprang out of a little Cavity between two Stones of a Wall from whence the Mortar was fallen, and which in the space of two or three Months, from a little Plant, as it appeared at first, shot out several Branches longer than a Man's Arm; and yet, when it was pulled up, in order to discover the Communication between its Roots and the Earth, none could be found. Now, whether this was occasioned by the Seed of neighbouring Elder-Trees, brought by the Wind and dropt into this Cavity, I shall not determine; it is sufficient for my Purpose, that it grew thus without any Appearance of Earth.

From whence have all those Juicy Fruits, as Grapes, Cherries, Goosberries, Currants, and a thousand others, their agreeable Liquors, if it were not from Water; which by the Concurrence of other Particles, acquires so many various Tastes, and, as we have hinted above produces, so many pleasant Drinks and Wines.

That this is true, the Chymists know full well, who by distilling not only these Juicy Substances, but likewise all other Plants, from the hardest Woods of Trees to the meanest Shrubs (to say nothing here of all the Parts of Animals, that are supported by

by those Plants) even from Horns, Bones, Ivory, and other Matters, without the addition of any Liquid ; do plainly shew by the Liquors coming out of them, and which the most ignorant Person cannot suspect to be in them, how great a share Water has in the Composition of the aforesaid Things.

To pass by here what some famous Chymists themselves have pretended, that the Foundation even of Metals and Minerals is Water only ; which therefore, if one may believe 'em, as well as Living Creatures and Plants, may be reduced to an Equilibrating Water, by the help of their Renowned *Alcahest*. But we don't insist upon this, because if for many Reasons it is not to be judged uncertain, yet it is still very dark and obscure. However, this is at least an undoubted Truth, that neither Plants, and consequently, neither Man nor Beast, that use the same for Food, can be preserv'd without it, and that all of 'em do for the most part consist of Water.

SECT. V. *We do not here enquire, whether Water be a Simple or Compound Body.*

I Do not here dispute, whether Water is to be consider'd as a simple Substance, the Parts of which are all of the same Figure ; and which, as it happens in Ice and Snow, joining themselves together, may compose the solid Bodies of Plants ; or, whether it is to be affirmed, that Water is a mixed Fluid, in which all sorts of Particles, proper for the Composition of Plants, are to be found, which, after the Evaporation of their Waters remain in the Plants, and contribute to the Augmentation of their Size and Weight, as has been attempted to be proved by Dr. Woodward, *Act. Lips. Anno. 1700. p. 87.* This is certain, that hitherto it could never be deduced from Philosophical Hypotheses, how it is possible, that Spirits, Salts, Oils, Earth,

and Ashes, &c. as has been shewn in the foregoing Experiments of *Van Helmont* and *Boyle*, should proceed from the same Water ; and which is more, how Water can be proper by producing so many various Smells, Tasts, and other Qualities in such various Kinds of Plants, to cause each of 'em nevertheless to grow up Regularly and Orderly, according to its own Nature.

SECT. VI. *Convictions from the foregoing Observations.*

IT is necessary to shew more fully in this Place, how far the Wisdom of our adorable Creator and Preserver exceeds the Comprehension of the greatest Philosophers, who unless irrefragable Experience had taught them all this, could never have believed, nor ever have imagined that this could have been proved from their assumed Principles. If the Parts of Water, or those that are mingled with Water, are formed by Chance only, are moved by Chance, and preserv'd by the same, since Chance Works without any Rule, how could the growth of Plants, that has come to pass in so exact an Order in innumerable Places, so many Ages, with so much Advantage to those that inhabit the Earth, ever be expected, or ever be hoped for again in following Times, if every thing were not directed and guided by an Over-ruling Providence ? I know very well what is usually affirmed upon this Occasion, by some about the Figures of *Pores* in the Plants themselves ; by others, about *Fermentation* ; and by others again, about a *Panspermia*, or a Disposition of the Water, containing in itself the Seeds of all Things. But it would not be difficult to shew here, that all these Hypotheses, and such lofty Names, in which there is so little of Truth, are much too weak in any manner to make manifest

fest the Ways of GOD in these Matters. And in case any one thinks he can deduce these things, of which he is entirely ignorant (as he certainly is of the manner how Water operates in all such Cases) from a natural and unknown Necessity, one need not prove any farther that he speaks without Foundation, since there can be no Demonstration of a thing that is entirely unknown.

SECT. VII. *An Experiment to shew that Water is changed into Earth.*

TO shew this, it is known, that the Evaporation or Exhalation of Water, as also the Distillation thereof, is a continual work performed in Nature without ceasing; at least, in Rivers and Seas, where the heat of the Sun is of any force; which causes the Matter to ascend in Vapors, and afterwards lets it fall again in the form of Mists, Dews, and Rains, and the like; after the same manner as the Chymists are wont to produce Evaporations and Distillations with the help of Fires.

Now that Water is hereby changed into Earth, has been experimentally shewn by Mr. Boyle; of which Sir Isaac Newton taking notice in his Book of Opticks, p. 319. uses these Words; *Water, by repeated Distillations, is turned into a solid Earth, as Mr. Boyle has discovered by Experiments*: Which is likewise confirmed by that diligent Enquirer, Robert Hook, and others, as may be seen in the *Aët. Lips. Anno 1707. p. 154.* saying, That all Waters, by frequent Distillations, are changed into a whitish and insipid Matter, which cannot be dissolved in Water again.

SECT. VIII. *Other Experiments relating thereto.*

As wonderful as this may likewise appear to some, it may, however, be proved without this Experiment, which gives us the entire Certainty thereof.

I. Because as often as we distil Water it always leaves some Earth behind it, which may render the foregoing probable to such as will not have the Patience to repeat those Distillations so many times after one another.

II. It may likewise be inferred from hence ; forasmuch as every one knows that the Plants which have been already proved capable of being produced by Water only, are subject to Putrefaction ; and are finally changed certainly for the most part into Earth.

III. This seems likewise to be plain, because the said Mr. *Hook* says in the before-cited place, that Sea-Water, tho' cleared as much as possible from all its Sand, yet being evaporated, does still leave some behind it.

An extraordinary Account whereof was communicated to the Royal Society in *England*, by Dr. *Robert Plot*, made upon the Salt-works in *Staffordshire*, which may be seen in *Act. Lips.* 1684. p. 244. where one Mr. *Collins*, writing about the same, says, That the great Quantity of Sand proceeding from all Pickles, whether it be from the Salts of the Springs of the Sea, or from those that are dissolved in Common-water, was found to arise only from the boiling, before which there was none observed to be contained in those Liquors: Forasmuch as after having been filtrated or strained through an eight double *Holland-Cloth*, they did not leave behind them the least Marks of Sand. Which Experiment, at the request of the said
Dr.

Dr. Plot, having been again repeated with great Exactness, occasion'd some farther Speculation, as may be seen in the said Account.

IV. Now, that Water may likewise be turned into a solid Body by Art, is plain from the *Sal Mirabile* of Glauber, which, according to his Assertion, will congeal all Liquids. And I have found Rose-water changed thereby into such a hard and petrified Matter, that being shaken about the Bottle which contained it, it burnt one of the sides thereof. I have not made the Experiment upon other Liquids, having no more of the said Salt by me; and a new Preparation of it required a little too much Attendance, to meet with the exact degree, whereby the Salt might be reduced to Powder without dissolving, which is however necessary in this Case.

I shall here add one instance more, that occur'd to my late Brother; who having first separated, by Sublimation, all the Volatile Salt from the Liquid Matter, which the Chymists call the Spirit, and which was distilled in Horse-dung, was just about throwing away the Remainder that smell'd strongly of Fire, and in which he could discover no sign of any more Volatile Salt; but however, to satisfy his Curiosity about the said Liquid, he thought fit to Distil it over again in Oven-Ashes, filling the whole *Still* after an uncommon manner up to the Top, where the Helm stands with Ashes; and putting Fire under it, it yielded a very clear Liquor, which as long as the Joints are stoppt, was as fluid as Water; but upon pouring it from the Recipient into a round and thick Pint Bottle, he found, that as soon as ever it was in it, that it was changed into a white, solid, and hard Body, like Marble, without the least Appearance of any Moisture or Fluidity in it; and this

solid Body assumed the perfect Figure of the Glass before it, just as melted Lead is used to do of the Mold in which it is Cast ; having viewed it many times with Amazement afterwards, whilst it retained the same Figure and Condition for several Months, at last, and by little and little (the Bottle not having been well stoppt) it returned again to a liquid Substance of a Smell exactly like, if not exceeding the strongest Spirit of Hartshorn, or Sal Armoniac.

I thought fit to give an account of this matter here (since the Chymists hold that this Liquor, when all the Volatile Salt is, as far as possible, separated from it, to be nothing but a mere *Phlegm*, or Water containing perhaps a few Oleaginous Particles in it) to the end, that I might shew how little Knowledge the greatest Enquirers have yet attained to, of the internal Structure and Disposition of that which they call (and justly too, according to all Appearance) Water : And after how many Ways it may be proved, that the Water of which we are now speaking, is capable of being converted into solid Bodies ; to say nothing here about Ice, which when dissolved, is turned to Water again, and therefore does not seem to have undergone any real Change.

SECT. IX. *That living Creatures, Plants, Minerals, and even Metals themselves are produced from Water, shewn Experimentally.*

I RECOMMEND it to the Over-weaning Naturalists, to prove how it may be consistent with their Hypotheses :

I. That from Water not only Plants ; and from them, when treated after a Chymical manner, Spirits,

Spirits, Oils, Salts, and a Terrestrial Substance or Ashes are produced, but ;

II. Living Creatures themselves are likewise beholden to Water, if not altogether, yet in a great Measure, for the Substance of which they consist. This is plain, because they are nourished by Plants and Water ; and the Distillation of all solid and fluid Parts of their Bodies, even of the very hardest, such as their Bones, Horns, and Teeth (as has been said before) experimentally shews, that Water is a great Ingredient thereof.

III. That besides Plants and Animals, even Minerals and Metals, proceed from Water. Thus we see in the aforementioned Experiments, that Earth proceeds from it ; which is likewise reckon'd among Minerals : And particularly by the Experiments related in the *History of the Royal Academy of Sciences in France, for the Year 1708*. that from the Ashes of Plants (which have been shewn above to grow out of Water) Iron can always be extracted by the Loadstone. How all these things come to pass, has not yet been rightly proved by any one that I know of ; but this plainly follows from thence, that our Knowledge of the real Essence of Things does not extend itself very far ; and that the most haughty and Strongest Mind must be forced to acknowledge here, that there does daily appear in Nature a manner in which Plants and Animals are what they are, and according to which, Water does likewise operate, which is impossible to be deduced from any of their Hypotheses or Principles.

I beseech them therefore once again, to consider with themselves, whether they have any cause to lean so much upon their own Understanding which has not hitherto been able to teach them, how a Plant grows, and of what it consists,
and

and what uses so common a Matter as Water, which has been examined and enquired into after infinitely different Ways, has in the World ; and therefore, whether they can think that they judge wisely, that this their Understanding does not only instruct them of the Nature and Disposition of that Universe, containing all these particular Matters that are unknown to them ; but moreover, that it is capable to determine, whether the said Universe were Eternal, and how it subsisted from all Eternity, or whether it had a Beginning ; in which they act just as wisely, as he that pretends perfectly to understand the whole Structure of a Watch, and yet is forced to confess, that he is ignorant how the least Wheel thereof is made. However, the Labour that is bestowed in the Contemplation of WATER (as much of it as there remains still unknown) will be abundantly compensated, if it only serves to convince Philosophers of the weakness of their Understanding ; whose great Presumption is oftentimes the only Stumbling-Block over which so many have fallen.

SECT. X. *The Ascent of the Water into the Air.*

BUT to go on to something else :

Could any Body, that had never seen it, believe, that this Water, which, on account of its greater Weight than the Air, is seen to descend in Rain, Dew, Snow, and other Forms, can be made to ascend into the Air, and there to compose the Clouds ? Tis true, that as in many other Matters, so likewise in this, the Custom of seeing a thing frequently happen, makes it seem to be the less strange or wonderful ; but it must however be confessed, that this is justly reckon'd among the Wonders of the Almighty in many Parts of the Sacred Writings ; as in *Psal. cxxxv. 7. Jer. x. 13. and li. 16. He causeth*

seth the Vapours to ascend from the Ends of the Earth; he maketh Lightnings for the Rain: He bringeth the Winds out of his Treasures. If ever he took the trouble to consider the various Opinions of the greatest Naturalists thereupon. We need only read what Mr. *Mariotte*, *Movement des Eaux*, p. 96. and Dr. *Halley*, *Act. Lips.* Anno 1692. p. 308. have said upon this Subject, to convince us, that the cause of this Ascent of Vapours is not so easie to be discover'd as some have imagined.

SECT. XI. *How such Ascent happens,*

I SHALL not here enquire, whether this Opinion of Mr. *Mariotte*, in this Matter, be the most probable, namely, that there are little higher Cavities or Holes in the Air, thro' which the smallest Particles of Water being raised upwards, perhaps by the Pressure of the lateral Air, may pass, but at which the biggest are stopt: Nor, whether we may more rightly suppose with Dr. *Halley*, that a little Particle of Water may be so far rarified and blown up as a Bladder, by a warm Matter, that its Diameter, in Breadth, Length, and Thickness, may be ten times as large as it was before; in which Case this Particle may fill a Space a thousand times bigger than the former; retaining nevertheless the Weight only of one Particle of Water, which had been found to be but eight hundred or nine hundred times as heavy as just so much Air in Magnitude; and therefore, according to the Laws of Hydrostaticks, as long as it remained thus rarified, it would continue ascending in the Air, exactly after the same manner as a solid piece of Glass, which in such a Condition would sink down into the Water, may be blown up into a round Bubble, and thereby with the same Weight,

occupying

occupying more place in the Water, would ascend and float upon it.

I leave the Arguments of these great Men to their own Weight; but forasmuch as the Authors of them acknowledge, that they believe, that there may be other ways, by which the Ascent of Water, which is heavier, into the Air which is lighter, may be explain'd; the following (which I therefore take the liberty to propose here) seems likewise to be one of those; the rather, because it is not so much founded upon an Hypothesis, as upon Experience.

SECT. XII. *Experiments shew that Air does likewise adhere to other Matters.*

To shew the same, it is known:

I. That Fire is lighter than Air; this wants no farther Proof, forasmuch as we see with how great Velocity all Flames ascend into the Air.

II. That lighter Matters can stick and fasten themselves to heavier: This appears in most Liquids, which adhere and hang upon other Matters heavier than themselves.

Accordingly we see, that the Air (which, tho' fluid, yet very moist) does cleave to many other Substances. To prove this, we need only throw a few rusty Nails into a Glass of clear Water; and if you view them sidewise, you will see many little Air-Bubbles cleaving to them.

And to the end, that it may not be thought that this adhering Air proceeds from the Water itself, I find by my Notes of the 21st January 1696, that some little pieces of Rusty Iron and Brass were thrown into Lye, in which there is no Air, and presently some Bubbles appeared upon them; and upon exhausting the external Air, which gravitated upon them, the said Bubbles became larger, and

and by their Expansion, shewed themselves to be Air ; and this appear'd the plainer, because if one rubbed off with the Finger, those Air Bubbles, that remained upon the Iron whilst it was under the Lye ; one saw, that how much soever the Impending Air was drawn off with the Pump, there did not appear one new Bubble ; so that it is plain from hence, that the Air will cleave to solid Bodies, and even to Metals themselves, which perhaps may also be the cause of Rusting.

Now that Air does likewise adhere and mix it self with Water, is sufficiently known to those that have ever seen what a Quantity of Air Bubbles appear when the Pressure of the Air is removed by the Pump from off the Water.

SECT. XIII. *Experiments to shew that Fire will cleave to solid Bodies.*

III. Now as Air, so likewise can Fire cleave to heavier and solid Bodies. This appears from Flint-stones, and other Bodies, not easily reducible to Fluidity when they are made red hot. For that the heat thereof is to be attributed to the adhering Fire-Particles, and not, as some Philosophers think, to the swift Motion of the small and fine Parts, whereof these and other Bodies are composed, appears from hence, that in case the Parts of the Flint itself should be put in such a violent Motion, it would lose its Solidity and be dissolved.

But for a farther Certainty of the Matter, one need only read what Mr. Boyle says in his Book *de ponderabil. part. flammæ*, upon several Experiments there recited, where he shews, that even Copper, Tin, Steel, Silver, Pewter, burnt Hartshorn, Chalk and Coral, become heavier by the Particles of Fire that cleave to them. And to know that this encrease
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of the Weight, did not so much proceed from the Parts of other gross Bodies mingled with the Fire, as from those of the Fire itself; one may see there that some of those Bodies being wholly shut up in Glass, became heavier only by the pure Flames of Brimstone, or of Spirit of Wine; which could not happen otherwise than from the small Fire Particles that must first have penetrated the narrow Pores of the Glass. [See the said *Boyle de penetrabilitate Vitri à ponder. part. Flamm.*]

SECT. XIV. *Fire will likewise cleave to Water, proved by Experiments.*

IV. Now that Fire can likewise joyn itself to Water, may be shewn by setting a Glass, or rather a little Tea-Cup (to prevent the breaking of it) full of very hot Water under the Receiver of an Air-Pump; when you will often see at the very first Exhaustion if the Water be hot enough, or at least, at the second or third, so great a Motion in the Water, that, like boiling Water, it will run over the Brims of the Vessel. This Experiment may be very easily made by all that deal with Air-Pumps.

When we tried the same upon the 24th of December, 1705, there was a little Glass full of cold Water put under the Bell at the same time, which, according to Custom, did indeed disclose a few Bladders or Air-Bubbles, but no kind of Motion that was any ways comparable to that of hot Water; so that this last Motion seems to be more properly owing to the Fire than to the Water.

But to be assured thereof, and to satisfy the Objection, whether the Heat of the Air might not likewise be the cause of this more violent Motion in the hot Water, on the 21st of January, 1706, we heated some Lye, in which there is no Air, and put it into a little Glass under the Bell; and to prevent

prevent the Pump from being spoiled, if it should Chance to run over, we put the first Glass into a second : And we observed upon the second turn of the Pump (tho' there was no Alteration at the first) that the Lye, with a sudden bursting, flew out above both the Glasses ; which can only be ascribed to the Particles of Fire contained in it ; forasmuch as no Air ever mingles itself with this kind of Liquor.

Afterwards, upon the 7th of *June*, 1709, making the same Experiment again with Water, we filled two equal Tea Cups at the same time with boiling Water ; and putting one of 'em under the Bell, we found that the Bell itself, upon taking off the Pressure of the Air, and during the Motion of the Water, was very hot at the Top. Now, whether this proceeded from hence, that the Fire Particles being freed from the Pressure of the Air, and extricating themselves by their Motion from the Water, rising up to the Top, and passing thro' the Glass, render'd it hotter there than in any other Place ; or, whether it be only to be ascribed to the Vapours, we shall not here dispute ; but this is true, that the Water, which had undergone so many Motions in the Receiver, being taken out from thence, was much colder even to the touch of all that were then present, than that which was never put under it : Whereas, if it be supposed, that the Heat were caused alone by a greater Motion of the Parts of the Liquor, and not singly by those of the Fire, the Water that had been under the Receiver, and had been put into such violent Motion, should have been much hotter than that which had suffer'd none.

And thus it seems to appear from hence, that the Water under the Receiver had therefore lost more of its Heat than the other, because the Fire Particles, by taking away the Pressure of the Air, got
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an Opportunity of freeing themselves by their own Motion from the Water, from whence, being flown out, the Water remained less warm than that other, in which the pressure of the Air had hinder'd the Fire Particles from separating themselves so suddenly from the Water.

Now whether this adhesion of the Particles of Fire to Water may likewise be supposed to contribute something, and to be the cause either alone or jointly, of that Property of the Water whereby it extinguishes the Fire ; I shall not examine any farther here : Forasmuch as the giving a true Reason of such Extinction, as common, and therefore as unheeded as it may appear to many does (If I may speak my Mind freely in the Matter) require a great deal of Consideration.

SECT. XV. *Three Consequences from the last Experiment.*

To proceed, I have noted three Things, that seem to follow from the abovemention'd Experiment.

First, That as Water and Air are particular Substances, it seems, that we might conclude from hence, that Fire also should be esteemed as such ; and not be look'd upon, consider'd as only a swifter Motion of the Parts of all other Bodies. This may be infer'd from the Waters becoming colder, after it has been just put into Motion, as has been shewn, therefore need not be here repeated. It likewise seems to appear from hence, that cold and hot Water being at the same time put under the Receiver, and the Pressure of the Air remov'd, the hot Water, immediately after its great Motion, did not shew the least moving Particles, whereas there were several Stirrings observed in the cold by the Rarefaction of Air, a good while after. Now tis known

known, that by Boiling and Heat, the Air flies out of the Water, so that these Risings and Ebulitions seem not to be imputable to any other Cause than to the Fire-Particles that succeed and cleave to the Water, and which by flying away, leave the Water at rest.

Secondly, from hence it likewise seems to appear, that the Fire-Particles are very Elastical and Expansive: Forasmuch as we see, that by removing only the Pressure of the Air that keeps them down, they exert their Motion of their own accord, which is also a Property of an Elastic Body.

Thirdly, The last thing that may be infer'd from this Experiment, and may likewise be of use is, that the Fire which sticks close to the Water, as soon as it comes into an Air, which is thinner and less powerful in its Pressure, abandons the Water, and flies away from it.

SECT. XVI. *Water and Fire seem to produce a Composition lighter than Air.*

FROM all this it is to be observed, that Fire and Water being united and mingled together, may make a Composition lighter than so much Air, and which can ascend in it; just as Iron and Cork being fasten'd together, will float upon the Water, tho' the Iron be heavier than the said Water. I remember to have seen an Experiment very analogous to this, by throwing a Clod or Lump of unrefined Brimstone, and letting it sink in Lye, to discover whether it contained as much Air in it as Salt-petre, in which we found a great deal; but having taken off the Pressure of the impendent Air, we did not only see some little Bubbles swelling up, but what is chiefly remarkable here, some of the little Bits of Brim-

stone that were broken off, were driven upwards by these Bubbles, and when they burst, the Brimstone sunk down again. I have observed the same when Water was thrown into Salt, and the Pressure of the Air removed. From whence may be infer'd, that a lighter fluid Matter may joyn itself to a heavier, and make one Composition therewith, and ascend and float in a Liquor, in which the heavier, being alone, would sink. Thus Experience likewise teaches us, that a small Heat, and consequently a little Fire, can make Water evaporate and rise upwards, even without boiling: And so we also see all volatile Salts, such as those of Sal-Armoniac, of Hartshorn, &c. ascending by the Warmth of a Fire that is hardly sensible. The same does happen too in pure burning Spirits, and in all other things that are esteemed the most volatile by the Chymists.

And if this Adhesion of the Particles of Fire to these Matters, be not the only Cause thereof, it may at least be supposed from the foregoing, that it may be reckon'd a concurrent Cause: And it even seems to be more credible, that this Cause is more common than that by which the Water, before it is capable of turning itself into Vapours, must be rarified into a nine or ten times greater heighth, length and breadth: Which is no ways, at least very rarely, experienced in Substances that evaporate with so small a Heat; and in others, such as Volatile Salts, can hardly be supposed to happen.

SECT. XVII. *Water must be divided into exceeding small Particles, in order to be Evaporated.*

THE last thing that is required above all the rest, as being the chiefest Occasion of the Rising of Water into the Air, is, that it should be divided into exceeding small Particles; that it may be so much sooner enabled, in Conjunction with Fire, to make a compound Body lighter than so much Air. Thus we see in all Distillations, that there do not ascend great and entire Drops, but only very fine and small Particles. The same is plain in all Chymical Sublimations; as likewise in the Smoak of Fires made of Coal, Wood, Turf and the like, which being divided into very minute Parts, are carried up into the Air by the adhering Fire: But being collected into a greater Body, when they are turned into Soot, they become so heavy, that they will not ascend, till they be reduced by other Distillations, for instance, to Bodies of a much smaller size.

SECT. XVIII. *Vapours ascend both by Heat and Cold.*

BUT to make an end of this Enquiry; whatever may be the Cause of the Ascent of Watry Vapours, this is certain, that Water being heated, either by the Sun, or by our Common Fires, tho' in itself it is so much heavier than Air, yet it will be carried up into it.

Now, whether we are likewise to suppose that there are particular Particles which produce Cold, as Fire does Heat; and which cleaving to the Water compose a Body lighter than Water itself, and so cause it to ascend in Vapours, we shall

not here dispute ; this is certain, that we see Vapours ascending from the low Grounds in the coldest Weather, and when the Water is frozen hard ; and that even Ice and Snow are lighter than the Water of which they are composed, and consequently must evaporate : But of this hereafter.

SECT. XIX. *The Laws of Hydrostatics.*

To proceed ; it is well known to such as understand the Laws of Hydrostatics, that,

I. If a Body is to be carried upwards in any Liquor, an equal Bulk of the said Liquor must gravitate or weigh more than such a Body.

II. That in order to cause a Body to sink in a Liquor, an equal Bulk of the said Liquor must weigh less than the Body.

III. If you would have the Body neither to rise nor fall, but preserve its Place in any Part of the Liquor, an equal Quantity of the said Liquor must weigh equally with the Body, which may be easily proved by Experiments.

SECT. XX, and XXI. *The Vapours in the Air adapt themselves to these Hydrostatical Laws ; as appears by several Experiments.*

Now, if we suppose, that *Tab. XV. Fig. 1.* represents the Globe of the Earth, *WPQRS*, surrounded by the Air as far as *BAD* ; which being heavy in itself, and thereby capable of being compress'd, grows continually finer from below at *P*, upwards thro' *g*, and *F* to *B*, and consequently lighter ; because its Elastick Faculty dilates it more in proportion as the Pressure of the superiour Air is diminished, and, as it scatters the Parts of the Air from each other, renders it lighter in an equally large Space. And if we now suppose farther

ther, that this same Air is heavier below, at that Part of the Globe that lies between F and P, and lighter above between F and B, than the Water evaporated or mingled with Fire; so that about F G H, the said Air is of equal Gravity with it, it will follow from what has been just now mention'd, that the Vapours between F and P will ascend; that being raised to the Bounds of the Equilibrium, F G H, they will float like Clouds at F and I G; and being æquipois'd, will neither rise nor fall; but when raised higher, to B F, or H D, they will descend.

This will happen much after the same manner, as when you pour Quicksilver and Water into a Glass, and then throw in a piece of Iron, which will sink down into the Water, but float in the Quicksilver, till it arrive at the place between both of 'em, where it can meet with its Equilibrium, and there it will remain between the two Fluids, the uppermost of which, Bulk for Bulk, is lighter, and the lowermost heavier.

We must not imagine that these Notions of the Air are supported only by mere Hypotheses: *First*, Because it has been experimentally proved above, that the Air is of such a Property, that when it is pressed by any weight, the Parts of it are squeez'd closely together, and so taking up a smaller Space, the same Quantity becomes heavier. So that it having been proved before in *Contemplation XVII. §. XX.* by a Tube I F, (*Tab. XIV. Fig. 1.*) filled with Quicksilver, that the same Air, which without Compression is above of the bigness of F, when squeez'd closer by the weight of the Quicksilver, will lie in so much a smaller Space below at I, and consequently becomes heavier in proportion to its Bigness; so that, for instance, if we suppose that F, above, is ten times as large as I below, a Cubical Inch of Air will press or weigh

ten times as heavy at I, as at F; since, by the Compression below, there is ten times the Quantity of Air contained in the same Space I, as above at F.

And, *Secondly*, Which may serve for an Experimental Proof, because such as have climb'd those high Mountains, find it to be true, you may see, among many others, a remarkable Account thereof in *Varenius, Geograph. Gener. Lib. I. cap. 19. § 41*. Where somebody that climb'd up one of the *Carpathian Mountains* in *Hungary*, which are much higher than those of the *Alps*, saw the white Clouds floating in the Air below him, some of which were however higher than others, according as the Matter whereof they were composed, being lighter or heavier, determined their Equilibrium higher or lower; for that numerous Particles, and consequently of different Weight, are raised up into the Air, under the Denomination of Watry-Vapours, or other Exhalations, has been shew'd above in our Discourse upon *METEORS*. The said Person did likewise observe the Air in which he was to be so Calm and Serene, that it did not produce Wind enough to move the least Hair of his Head; notwithstanding that he had been sensible of a strong Wind in the lower Parts of that Mountain. But that which seem'd to be the clearest Proof of a greater thinness of Air, was, that in discharging a Musket, at the very Top of the Mountain, the Report or Sound of it was no louder than that which is produced by the breaking of a little Stick. Now how much the Rarefaction, or Thinness, of the Air contributes to the Diminution of Sound, appears by hanging a little Bell in the Recipient of the Air-Pump, and exhausting the Air from it; of which more largely in *Contemplation XVII. §. XXXVI*.

SECT. XXII. *After what manner Vapours float.*

Now, to draw a Conclusion from all this, it is easie to be understood, how the Waters, by being united to the Sun-Beams or Fire thereof (to say nothing of the Exhalations in great Frosts) are raised up into the Air in Vapours, where, according to the Laws of Hydrostaticks, they are driven and remain pendulous in a lighter Matter, as the Air is in this Case, without subsiding by their own Weight: But it would be of very little Use to all the Inhabitants of the Earth, both Men and Beasts, in case these Watry-Vapours should continue always floating in the Air, without ever falling down from thence. Now to form some Conception, how this floating of the Air may happen; Let us again suppose that from the Sea P, in the thick Air F P, (*Tab. XV. Fig. 1.*) there are some Vapours raised up to F; that at the Distance of F I G, from the Earth, the Air becoming something thinner, yet retains so much Density or Thickness, that tho' these Watry-Vapours, by reason of their not being rare or thin enough, cannot rise up higher to B, yet they are hinder'd by a sufficient Weight and Thickness of Air from falling down, and collect themselves there in high-flying Mists, which, when seen from the Earth, are called Clouds, as has been already experimentally shewn; whilst others that are heavier, cannot ascend farther than to K d; because, if they came into a higher Air, which was lighter, they would fall down again.

SECT. XXIII. *Experiments to shew how the Vapours can descend.*

I. IF now two Winds blow these Mists or Clouds with any Force, as I G, or F, from opposite Quarters, and thereby compel them to run against each other, it is easie to conclude, that they will be there collected into Drops, and so becoming heavier than the like Quantity of Air, will fall down; and the rather, because by the Motion of these Winds, the Fire that render'd them Lighter (after what manner soever it happens) gets an Opportunity of separating itself from them.

According to the first manner, we see in Distillations from Retorts or Glafs Helms, when in the narrow Parts of their Necks, the Vapours are compressed together; that they run into Watry Drops, and so descend; tho' just before, having Room and Liberty, they did ascend, and would have risen yet higher, without these De-files or narrow Passages.

'Tis likewise well known to every one, that a hot Liquor in which there are many Particles of Fire, becomes colder by the Breath or Wind of Peoples Mouths. Now that this happens, because the Fire-Particles are by such a Motion separated from thence, seems probable for the following reason; namely, that otherwise, if the greater Heat did consist only in a greater Motion of the small Parts of a Liquid Matter, the same, according to this Hypothesis, by the blowing, which encreaseth the Motion of the Liquor, would become hotter and by no means colder; whereas common Experience teaches us the contrary.

SECT. XXIV. *Vapours descend by the Separation of the Particles of Fire from them.*

II. IN case one only Wind be of so much Strength as to be able, by blowing from I to G (*Tab. XV. Fig. 1.*) to drive forwards the Vapour or Cloud I G, in a streight Line I Z, and so can protrude the whole or a part thereof to Z; it is plain, that the said Cloud is higher from the Earth, at Z, and consequently in a thinner Air. From whence it will follow, according to the above-mention'd Experiments made upon hot Water and hot Lye, in the Air-Pump, that the Fire, which by sticking to the Particles of Water render'd them lighter, will extricate itself from them, and ascending by its Lightness, the Water will become too heavy, not only to remain in this thin and light Air, but even in a thicker and a heavier near the Earth, and so will be turned into a descending Dew or Mist, or Rain, Snow, or the like, according as the Watry-Vapours are either rarified or compress'd.

SECT. XXV. *Experiments, proving the Descent of Vapours by the Air's becoming lighter.*

III. NOW, that the Air (which being near the Earth at P, is otherwise heavy enough to keep up the Vapours, and to cause them to float about F) is likewise frequently, for other Reasons, turned into a thinner and lighter Substance, and so gives an Opportunity to these Vapours to descend, has been already shewn in the preceding *Contemplation*, §. XVII, and XVIII. in the Glasses of the Air-Pump; and the Barometers do upon many occasions, furnish us with Experimental Proofs thereof; in which the Quicksilver descending commonly upon

on the least Weight of the Air, does prognosticate, that the Watry-Vapours are about to descend in Fogs or Vapours, or otherwise from the Air.

SECT. XXVI. *Cold will produce the same Effect: Shewn experimentally.*

IV. BESIDES this, the sudden Cessation of the Warmth of the Air seems to give an Opportunity to the Vapours, which, by the said Warmth, had been raised up in great Quantities, to be precipitated by the Cold, and to be turned into Fogs or Rain. An analogous Example thereof may be seen in Distillations that are performed by what they call *Serpents*, or *Worms*; and something like it is also found in Chymical Crystallizations; in which we see, that the Salts that float and are dissolv'd in the Water, whilst warm, do coagulate and subside as soon as the same becomes cold. But whether it happens so in the Air, or after what other manner it is done there, since the Nature of Cold is not yet so fully known to us as many think, we shall not enquire farther here.

Now how many Causes soever there may be, besides those that we have already mention'd, whereby the Watry-Vapours that are raised up in the Air may be made to descend; this is certain, that both their Ascent and Descent are owing to a wonderful Law of *Hydrostaticks*.

Now can any one imagine, that all this comes to pass without a wise Direction, and that it is by mere Chance that so vast an Army of Vapours in the great Space of the Air are every where subjected to the most exact Hydrostatical Rules, in such an infinite number of Occasions and Accidents? Is there no want of an Intelligent Being

ing to oblige such a prodigious Quantity of Waters, turned into Clouds, to remain floating in the Air, which are often observed to descend in mighty Showers, in rainy Springs and Harvests, or other Seasons ? To say nothing now of the various Ways and Forms in which they descend, and whereby so many Cisterns and other Receptacles of Waters, as well as Ditches, Canals, and Ponds, are filled in so small a time : But which is a great deal more, by which such vast Rivers swell so suddenly, and over-flowing their Banks, do frequently cover whole Districts of Lands.

SECT. XXVII. *The Motion of Vapours from one Place to another, is necessary.*

BUT now if these Vapours had no other Quality or Property in them than barely an Ascent and Descent to and from the same Place, and that those, for instance, represented in *Tab. XV. Fig. 1.* by F, having been exhaled from the Sea at P, should fall down again in the very same Place ; and that they were to be moisten'd only by no other than such Watry-Vapours as are drawn from its own Bosom, there would very little Advantage accrue to its Inhabitants from thence. How many Rivers would then be quite dried up, which at present have their Rise, or at least receive an abundance of Water from the Rains and Snows that descend from the Mountains ? How should the wild Beasts in *Arabia*, and such like Countries of *Africa*, which thro' their Drought afford no Water at all, assuage their Burning Thirsts ? What Fruits would the now most fertile Places produce, in case none of the Water, which by the Heat of the Sun is exhaled in other Parts of the World, were brought, and made to fall down upon them ?

Can

Can a miserable Philosopher think again, that he owes no Thanks to his Creator, that the Waters which are exhale'd in the *Torrid Zone*, and other hot Countries, are, by the Winds that drive Clouds, brought home to him, yielding him Drink, and making fruitful that Part of the Earth where he inhabits ?

SECT. XXVIII. *An Experiment, shewing that the Watry Vapours leave their Salts behind them.*

Now since most of the Vapours that are so beneficial to the whole World are chiefly exhale'd from the Sea, and yet those Waters, by reason of their Saltness, are unfit for the Purposes to which they are destin'd ; insomuch that Men would die of Thirst in the midst of the Sea, and no Herb or Plant, to which the Salt-Water should be applyed, could live and grow therewith, as by sad Experience is but too well known in Lands that have been overflow'd by the Sea ; Can any one again imagine, that it is by mere Chance or ignorant Causes, that the Sun does only exhale the Fresh Watry Vapours out of the Sea, and collect them into Clouds, whilst the Salt, with which they were at first impregnated, by reason of its being so much heavier than Water, is left behind ?

That this is true, may be proved not only from the Freshness of Dew, Rain and Snow, but one may see, whenever one will, a like instance, by setting Salt-Water upon the Fire, and causing it to exhale in Vapours, or by drawing them off in Distillation ; in which Case you will find the Salt remaining at the Bottom. The same we see happen in Salt-works, by the Sun's Heat, and in the Salt-works with our common Fires. So that after this manner two great Things come to pass, without which the whole Race of Mankind would
soon

soon be extinct ; namely, that *First*, Sea-Water is divested of its Salts, and render'd fit for Drink, and so many other Uses ; and *Secondly*, that the said Salt becomes very serviceable to Men.

SECT. XXIX. *If the Earth were mathematically round, the Rains would seldom fall where they were wanted.*

Now, if what has been said before be not sufficient to convince our unhappy Atheist, let him stop here a little, and seriously reflect with himself, after what manner those Countries that lose their Moisture by so violent and continual a Heat (and which are therefore so dry and so barren) can be brought into a Condition to support their Inhabitants with Meat and Drink : And in case he could order Matters as he thought fit, what Methods would he take, constantly to provide the same with a sufficient Quantity of Water from the Heavens, and to collect the Vapours in that vast Ocean of Air, and make them descend upon those Parts of the Earth only, where they are chiefly wanted. And that we may not give him the Trouble of charging his Imagination therewith ; let him but say, whether he should not esteem that Man for a very understanding Person, who had invented a way, which as long as Heaven, Earth and Sea remain as they are, will always be useful, and whereby those dry and uninhabitable Countries might be so well water'd, as to be equal in Fruitfulness to any others.

SECT.

SECT. XXX. *Convictions upon Occasion thereof.*

TO give an Instance of such a Case ; Let a Man cast his Eyes only upon the Island of *St. Thomas*, which is under the Line, or upon that of *St. Helena*, lying between the Tropics, where the Heat of the Sun is exceeding strong ; since all the Vapours that ascend from the surrounding Seas, seem to be more likely to fall down again directly into the same, than upon either of these Islands, the solid Parts of which reflect the Rays of the Sun with greater Force than the fluid Parts of the Sea : Can any one think, that it happens without the wise Design of the Creator, that there are *high Mountains* found upon those Islands where these Vapours are collected in so vast a Quantity, that they are capable of rendering whole Brooks and Rivers sufficient to provide Drink for Animals, Nourishment for Plants, and Fertility to the Earth, in such burning Regions, in great abundance.

SECT. XXXI. *Mountains serve to collect Watry-Vapours from the Air.*

NOW, that whatever is here said is true, whatever different Sentiments some People may conceive about the Mountains, can be supported by a Cloud of Witnesses, as well as Trials and Experiments.

Let us only peruse the Description of the Island of *St. Thomas*, in the *little Atlas of Mercator*, in which we shall find these Words ; *In the Middle of this Island there is a Mountain very full of Woods, and continually cover'd with such thick Clouds, that from the said Woods there proceed Streams and Brooks sufficient to water all the Sugar in the Plantations ;*
and

and, which is very remarkable, when the Sun is at the highest, this Mountain is mostly cover'd with Clouds.

The same thing is related by Mr. Robbe in his Geography, concerning the Island *Madagascar*, viz. that notwithstanding that it is so situated, as to be exposed to the strongest Heat of the Sun, which, as at *St. Thomas's*, is twice a Year perpendicular over the Heads of the Inhabitants; and one would therefore be apt to think, that every thing is destroyed with Heat and Drought, yet in the middle thereof, there are a great many Mountains and Woods, from whence many Rivers are observed to run on all sides.

I find the same noted by Mr. *Warren*, or rather in his Extract in the *Act. Lips.* 1691. p. 98. That the Clouds and Fogs hanging over and about the Mountain, called the Pike of *Teneriffe*, do run down every day about Noon, in so vast a Quantity, that they do abundantly fill the Place with great Rains, which never fall upon other Parts of that Island.

To instance in no more; that this is a useful Phænomenon in Nature, may appear from the general Geography of *Varenius*, cap. 9. §. 9. who proposes this Question; *Why there are often observed Rains, Fogs and Snows upon the Tops of Mountains, whilst in the adjacent Valleys the Weather is bright and clear, and none of these Meteors are to be found?* And then he proceeds to say; *This is confirmed by such as have travelled over the Mountains in Asia, Peru, and other Countries, viz. That they frequently observed Rain, Snow and thick Fogs upon the Tops of those Mountains; but when they descended into the Valleys, they met with nothing but Fair Weather: We find the same sometimes in the Mountains of our own Country.* Accordingly, Mr. *Isbrantz Ides*, observed in a certain District upon the Frontiers of *China*, that the Clouds shewed themselves over the Mountains, but not farther.

SECT. XXXII. *Fountains and Rivers proceed from Mountains.*

MOREOVER, that Fountains and Rivers proceed from that Collection of Vapours which is continually made upon Mountains, is very learnedly proved by that Great Mathematician Dr. *Halley*, whose Dissertation thereupon has been published in the *Act. Lips.* 1692. p. 308. the Substance whereof is briefly as follows; *This Speculation about Fountains is by no means a naked Supposition, but is founded upon Experience; to the acquiring of which my stay at the Island of St. Helena (which is likewise under the Torrid Zone, and one of the hottest Parts of the Earth) gave me an Opportunity; where, upon the Top of a Mountain about 2400 Foot above the Sea, the Vapours and Dews of the Night, even when the Sky was clear, descended so thick and so fast, that I was forced every Quarter of an Hour to wipe the Glass of my Telescope, and my Paper was in a moment so damp, that it would not bear Ink. From whence one may conclude how great a Quantity of Water must be collected upon those Mountains in a very short space of Time, which are much higher and larger than this is; and which are observed to run in a long Ridge, so long as to fill whole Countries, such as the Pyrenæan Mountains, those of the Alps, the Apennine and the Carpathian, in Europe; the Taurus, Caucasus, Imaus, and others, in Asia; the Atlas, the Mountains of the Moon, and many more, that have no name, in Africa; from whence proceed the Rivers of Nile, Niger and Zaire, in America; the Andes, and the Apalatian Mountains, each of which do far exceed the common Height to which Vapours of themselves do descend, and upon the Top of which the Air is so cold and rarified, that it can support very few of the Vapours floating in it, and which are driven thither by the Winds.*

SECT.

SECT. XXXIII. *The Furnishing us with Springs and Rivers is a Principal use of Mountains.*

THE above-named Gentleman is of Opinion, and that not without weighty Reasons too, that one of the chiefest Uses of Mountains is to collect the Vapours in the Air, and to turn them afterwards into Fountains or Springs, then into Brooks, and last of all into Rivers, and so to transmit them from their respective Heighths.

I shall not here enumerate the Difficulties that are proved by the said Dr. *Halley*, to stand in the way of those that pretend to deduce the Origin of Rivers from other Causes : Wherefore he seems to lay down the aforesaid, as almost the only ones. And it suffices for our Purpose, that tho' there were any others, yet these at least may be esteemed some of the chiefest. I have dwelt the longer upon this Matter, because it seems to serve for a great Proof of the Wisdom of the Creator to such as will consider the whole without Prejudice.

SECT. XXXIV. *Convictions from the foregoing Observations.*

NOW, If there should still remain any of those unhappy Persons, who endeavour to maintain, that every thing has acquired its Form from necessary Causes, or simple Chance, upon the following or the like Hypotheses ; namely, that so many and such amazing great Bodies as the Mountains, are of no use at all ; and who, if they had had the fashioning the Globe of the Earth, according to their own Humours, they would have made it without them, and have given it a perfect round Figure, without the least Inequalities : Let them but once seriously consider the above-mention'd

Experiments, and from thence learn, *First*, the great necessity of these protuberant Parts of the Earth; without which the Globe would altogether, or at least in a very great Measure, be deprived of Rivers, things so useful, and which are such great and noble Tokens of the Goodness of our Creator. And *Secondly*, Let them ask themselves, whether they must not be convinced thereby, that those speak nothing but the Truth, who affirm, that all these Argumentations about the Usefulness of such Glorious Parts of the World, have no manner of Foundation in the things themselves, but only in the Smallness of the Understanding of these Cavillers; and that if the Ends which the Creator had in view, were made known to them, what they urge against the Greatness of that Supreme Director, would become a Demonstration of his Goodness.

SECT. XXXV. *Egypt moisten'd by the Nile without Water.*

I MUST confess, that it has many times appeared to me as a sensible and visible Proof of the Gracious Providence and Government of GOD, namely, what has been published and confirmed by the General Testimony of all that have travelled there, concerning the particular State and Condition of *Egypt*: This Land, which is all Flat, and without any Mountains, as *Monconys* and others write, is seldom or never Water'd by Rain; it lies in the middle of dry Countries, and is almost surrounded with the most barren Desarts, inso-much, that of itself it is entirely unfruitful, and consequently would be uninhabited.

Now can any one imagine, that it comes to pass by mere Chance, that the Mountains of the Moon are placed in those Parts of *Africa*, where the

the Countries are burnt up with the Sun, and that from the said Mountains, there flow such mighty Streams, which, being collected together, make the Sea or Lake of *Zaire*, from whence proceeds the River *Nile*, which running thro' all *Egypt*, discharges it self by many Mouths into the *Mediterranean* Sea ; and, which is most for our present Purpose, that it yearly Swells and Rises over its Banks, and overflows all the Country ; so that the Towns that are Built upon any Eminences, appear like so many Islands, whilst the Flat Country lies under Water ; and by such Innundations, this Country, which is otherwise dry, and almost burnt up, becomes as Fruitful as any other that are usually Water'd with Rains.

SECT. XXXVI. *The Fertility of Egypt.*

It is wonderful what the Geographers, and among them Mr. *Robbe*, in his Description of the World, mentions of the Fertility of this Country ; namely, that these Waters of the *Nile*, with which all *Egypt* is over-flown, are wont to leave such a Slime and Mudd behind 'em, as being dried, renders the Ground so very Fertile, that the Trees are almost Laden with Fruits ; and that if the *Egyptians* themselves were not so Lazy, but would Cultivate and Sow their Lands after the first Harvest, and Collection of the Produce, they would yield a Second Crop in the same Year : This is certain, that by reason of the Strength and Fatness of their Country, the Inhabitants are oftentimes obliged to moderate the same by mixing Sand with the Earth. Many do likewise ascribe it to this Cause, that their Flocks are more numerous than in other Countries, and that their Sheep bring forth Young twice a Year, and the like :

Some Authors say the same of their Women ; that they have often Twins, and sometimes more at a Birth.

SECT. XXXVII. *Convictions from the foregoing Observations.*

To return now to that Cause of the Rivers, the Collection of Watry Vapours upon Mountains : They that are still so stark blind or stiff-necked, that they cannot, or will not, see any Tokens of Divine Wisdom and Goodness in each of these Wonders ; Let them again Contemplate some of them with us, and return to *Tab. XV. Fig. I.*

Let them then suppose, that upon the Globe W K R S, there dwell a Number of Men and other Creatures, in the Structure and Composition of each of which, there appears, as has been shewn before, an amazing Skill and Contrivance.

Let them next own, as it is true, that unless the Earth C X Y T, were moisten'd with Water, and that fresh too, the said Earth would be entirely Barren, and all the Living Creatures upon it would perish with Hunger and Thirst ; and tho' an abundant Procreation might seem capable of making good the Loss, yet not one of their own could live a Month after it was brought forth.

Let them consider, that those great Seas, and vast and deep Lakes C W S, how great a Quantity soever of Water they may contain, would not be able to render the smallest Tract of Land Fruitful ; nor to afford to one single Man or Beast, as much Drink as were necessary to keep them alive by reason of their Saltness.

Can they then in this dismal State of Affairs, imagine, that it is by Chance, and without any Wisdom, that such a glorious Body as the Sun, besides the Light and Warmth it communicates to
us,

us, does also render us this Service, that the Waters of the Sea at P, being rarified by its Beams, are exhaled and ascend in Vapours to g and F; and leaving their Salts behind them, for other Uses, do compose the Clouds F, I G, K d, above in the Air; which falling down again in Rains or Fogs; in Dews, Hail or Snow, afford a fresh and fertilizing Moisture to the Earth, and Drink to Men and Beast.

Can he daily see this Ascent of Watry Vapours, and say, that it is performed by Chance and without Wisdom? Notwithstanding the manner by which 'tis brought about, is allowed to be wonderful, by the greatest Naturalists, such as those learned Persons; Dr. *Halley*, and Mr. *Mariotte*, who are not ashamed to acknowledge the weakness of their Understanding in that Matter, and so must every one besides. And yet all this great Preparation would have been in vain, if a certain fluid Matter, which we call Air, had not been placed round the Globe at B A D.

But that which here seems to prove undeniably the Being of a G O D, is that, notwithstanding the Terrestrial Globe, be thus surrounded with Air, and that the Sun do continually shine upon the Sea and the Rivers, yet there would scarce arise from thence the smallest Vapours, if the said Air were as thin and as much rarified below at F P, as it is above, between B and F; and on the contrary, if the Air were as thick above, between B and F, as we now find it between P and F, few or none of the exhaled Vapours would ever descend in Rain or Dews, but floating in the Air, like Oil upon Water, would continue there, in which case also, the whole Earth would be dried up, and every thing living perish with Thirst.

Let me now again ask these miserable Philosophers, whether they can imagine, that all these things are thus disposed by mere Chance, and without a View towards any End? And that the Air, by its Weight and Elasticity, becoming more Compressed and Thicker below than above, was thus disposed with respect to the exhaled Watry Particles, that the Vapours would be seldom or never in an Equiponderating State therein, before they be raised to the height of the Clouds F or K. Whereas otherwise, in case the Air were of the same Thinness at P, or just above the Earth, as it is higher at F, to say nothing of the Distempers which would be occasion'd thereby, the continual Cloudy Weather, Fogs and Mists, would take away, or at least embarrass the use of our Sight.

To add one thing more, is it brought about by ignorant Causes, and without Knowledge and Foresight, that whereas so many other Kinds of Salts are incomparably lighter than Water, yet the Sea-Salt is heavier? which would otherwise, by ascending along with the Vapours, render all the Waters of Rain and Rivers useles and unnecessary, both to Living Creatures and Plants. Is it by Chance, that the Sun is placed at just such a Distance from the Globe, as to be able by its Warmth to cause the Waters to ascend in Vapours; and yet not so near as to Singe and burn up those tender Plants which received their Nourishment and Encrease from those Waters, and do chiefly consist thereof?

Have the Sun, the Sea, the Air, and the Salt, met one another in so small a corner of the World, which, with regard to the whole Extent thereof, is but a Point; I say, have they thus met by mere Chance, in order to furnish all the Inhabitants of the Earth with Meat and Drink? Is it owing to

Ignorant Causes, that they are endowed with so many necessary Qualities as have been before enumerated, and as are required for this only Purpose? If this be not sufficient; if no other Causes concurred, in order to Water the Earth with the Vapours descending from the Air, than the Lightness and Thinness of the said Air, or the Winds that drive them together, it is plain to every Body, that all the Parts of the Earth, without any Difference, would be equally Water'd; and that the Sea, which has no occasion for these Vapours, as well as those other Parts of the World, which for want of 'em would be uninhabitable, would each receive their Share; and it may be, those that least want them would enjoy the most.

Once more, let those Philosophers, with whom we have here to do, judge themselves; whether it be owing to mere Chance, that to the end, that those Countries which stand in most need of being water'd, may enjoy a greater share than others, such great Bodies as the Ridges of Hills and Mountains, are placed in or near the same. The use of which, as has been said before, is to intercept the Watry Vapours floating in the Air, to collect them, in a particular manner, upon their Summities or Tops, to derive them down from thence, and so to furnish such a Quantity of Water as may compose the requisite Brooks and Rivers which contribute so much to the Benefit of the Earth, and the Inhabitants thereof. To say nothing here of the number of Fishes and other Productions in these Waters, by the help of which the People, thro' whose Countries they flow, can Communicate their Fruits and Merchandizes to each other.

SECT. XXXVIII. *The Mountains collect Watry Vapours, first by the Winds.*

HERE we seem to have a proper Occasion to inquire into the Manner and Causes, how and why the Mountains are able to collect such a vast Quantity of Waters, to the end, that what has been said before upon this Subject, may be the more clearly understood.

How the Vapours are raised from the Sea, from P, to g and F (*Tab. XV. Fig. 1.*) by the Warmth of the Sun (and under the Poles, by Cold too perhaps) has already, in some manner, been endeavour'd to be shewn; as also how they are enabled to float in thin Air, as in different Stages and Degrees of Heighth as g, K, d and F, I, G; and moreover, why the said Vapours, being raised higher up to Z, by the Winds, or driven against one another by contrary Winds, and for other Reasons, do descend in Rain, Snow, and the like.

Dr. Halley subjoins another Manner to these; namely, that a floating Vapour or Cloud in E, being driven against the Mountain QNR, by the Winds at E, ascends to the Top N, and there finding itself in a lighter Air, cannot be any longer supported, but falls down in small Drops upon the Head of the Mountain, and from thence running down, fill the Cavities of the Mountains (which are supposed to be there, and so are often found to be) with Water; which running continually thro' the Orifice M, produces the little Brook MeT, or MeV; which joyning themselves with others of the like Nature form a large River.

It appears by this way, why the Waters are assembled in greater Quantities upon the Mountains,

forasmuch as opposing their Tops from Q R, to N, against the Winds which drive the Clouds m E, K d, &c. they serve for Barricado's or Cross Trees, and so do either force the Vapours to ascend into a Lighter Air, or forcing them against those tops, squeeze 'em together, whereby they become heavy and fall down again.

SECT. XXXIX. *Secondly, Vapours are collected by the Coldness of the Mountains, and Superior Air.*

AND as it is credible, that this does often happen, it should seem that the Winds are necessary thereto ; and that in case they failed, so great a Quantity of Water, according to all Appearance, would not be collected ; whereas the above-mention'd Experiments teach us, that the Tops of the Mountains, even in hot Countries, are not only encompassed by Winds at certain times, but continually with Fogs and Vapours ; so that besides this it seems, that a more settled Cause, and which does not always depend on the Motion of the Winds, must obtain here.

Now, whether this can be deduced from the Cold of the Mountains themselves, and of the Superior Air surrounding their Tops, and to which the Reflection of the Sun-Beams does not reach ; or, whether it must be ascribed to their Heads being always hid in the Clouds, I leave to such as will enquire more strictly : This is certain, that by reason of the Cold they are often cover'd with Snow, and *Varenius* says, that, excepting in the Months of *July* and *August*, there is always Snow upon the Pike of *Teneriff* ; tho' none can be found this and the other *Canary* in *Islands*.

SECT.

SECT. XL. *Thirdly, Vapours are collected by Shadows, shewn Experimentally.*

WE have not here undertaken to write largely upon Natural Knowledge, not to repeat the whole History of Nature; but we cannot forbear observing however, that the great Shadows which these Mountains produce, do occasion a continual Cold Air about them. Thus we read in the *Extract of the History of Bohemia, Act. Lips. 1682. p. 244.* That in a certain Valley of the Giant Mountains, at the hottest Time of the Year, there are very deep Snows, and that they have lasted there for 16 Years together, the old being of brownish Colours, by which it is distinguished from the latter Snows that are white and clear.

If then we suppose the Sun to be at O (*Tab. XV. Fig. 1.*) and a Mountain QNR, casting its Shadow, as at QEX; where the Sun-Beams are hinder'd either by other Mountains lying about it, or, because the Sun seldom Shines upon that Side, from ever Heating the Air to such a Degree as is found in the next adjacent Air: It is plain, that the Air within the Shadow QEX, will be a great deal Colder than that which encompasses the Mountain out of the Shadow. Now it has been proved Experimentally in the foregoing *Contemplation*, that a Warmer Air having access to another which is Colder, if they be not of a too different Thickness, will be rarified and driven with a Wind and Stream towards the cold Air. Now if this should be applied to the Air, which is here not only below, but also above, and on the Side, or rather round about the Shadow, we shall see how this Air, with all the Vapours in it, are driven to the Shadow. For that the Vapours floating in the Air do continually follow its Course,

is plain, and will appear from a boiling and steaming Pot of Water, set in a place where there is no Wind, from whence then it may be concluded, that the Air with its Vapours, coming into such a Shadow, and being there deprived of its Elastic Force by the Cold, will be immediately followed by more Air which is Warmer, and consequently whose Elasticity is Stronger, and so produce an entire and gentle Stream of Air and Vapours, if not prevented by other Winds, and moisten those Places with continual Vapours.

SECT. XLI. *Fourthly, Other Shadows likewise give occasion to the Concourse of Vapours, proved Experimentally.*

Now, that this also, among other Reasons, must be laid down, why the Vapours seem to be drawn in a continual Stream to the Mountains (but really and properly are pressed thicker from all sides) and why the Mountains are many times observed to be clouded (of which we have given several Instances above) every one that understands the Properties of the Air, may easily infer from what has been said. That in Shadows the Vapours of the Air are collected, does certainly appear from the Night, which is nothing but the Shadow of the Earth, and in which it is well known, that the Vapours and Dews fall thicker than in the Day time. Thus we see the Descent of Vapours in the Night-time was observ'd by Dr. Halley, in the Island of St. Helena. And we find in the *Memoirs of the Royal Academy of France*, for the Year 1699. p. 128. a Method invented by Mr. de la Hire, to hinder the Dews of the Night from sticking to the Glasses of the Telescopes. Now Experience teaches, that in the Mornings too the Mountains are moisten'd with Vapours (see
Va-

Varenus's General Geography, lib. i. §. 5. p. 157.) because those Places that are within the Shadow of the Mountains, are much Colder at Night than other Places that are out of the Shadow. Thus we likewise see from the foregoing, that in the Islands of *St. Thomas* and *Madagascar*, the Mountains which collect the Waters from whence the Rivers are produced, being cover'd with Woods, and consequently more Shady, do make the Air more cool and more Elastick; by which Means the Waters are yet more encreased upon the same: And that it may not be thought that this is inconsistent with what has been said above, of the Descent of the Waters more strongly at Noon from the Mountain called the *Pike of Teneriff*: Let it be consider'd, what was farther said about this Mountain, namely, that the Snow which cover'd the Top of the same, being melted by the Heat of the Sun at Noon, caused the Waters to run down more violently at that Time.

I think, that these Experiments may serve for Proofs, that the Cold produced by the Shadows of the Mountains in the Air, may justly be counted one of the Reasons why, so many Watry Vapours are carried thither in a continual Stream.

SECT. XLII. *Vapours sufficient to produce Rivers.*

THE only Difficulty that seems to remain, how there can ascend so great a Quantity of Vapours as may suffice to produce great Rivers: To answer which, we do not here pretend to maintain, that all Rivers proceed from these Vapours, or that they are the only Cause thereof; since perhaps, according to the Opinion of Others, the Sea entering into Subterraneous Caverns, may, by way of Filtration, leave its Salts behind it, and so produce

duce Sweet and Fresh Fountains : And besides, it may be, the Subterraneous Fires may cause these Waters that come from the Sea into the Cavities of the Earth, to exhale and ascend in Vapours, which being again turned into Water, by the Cold which they meet with above, may produce Fountains. But it is however a sufficiently probable Truth from what has been shewn before, that the said Vapours may justly be reckon'd among the principal Causes of Rivers. Since the Sea, and other Waters exposed to the Sun, do continually transmit Vapours upwards, which, being collected upon the Mountains, and coming down again in Rain, Snow, or Hail, are proper to produce Rivers which may flow a long time without ceasing and compose great Streams. This may be in some Manner inferr'd from the Observations of Mr. Mariotte in his *Treatise du Mouvement des Eaux* p. 25. who says, that in a heap of Rubbish, which was about three Foot high, and whose Superficies was little less than 500 French Fathoms (forasmuch as the Rain that fell upon it, and upon the Tops of the Neighbouring Houses could not Soak thro' by reason of the Hardness of the Ground) there was a continual little Stream of Water made below.

But the same will be yet better shewn hereafter, from the Calculation which the said Mr. Mariotte makes, concerning the Waters of the *Seine*, compared with the quantity of Rain falling upon those Tracts of Land from whence this River has its Origin (*see the said Treatise, p. 30, 31, 32, 33.*) by which it is proved, that in case there falls so much Rain Water every Year upon these Lands, that in case it remained there, would rise to the Height of 15 Inches, there would be 6 times as much as is requisite to run down the *Seine* in one Year; and in case the height of such Rain-water should amount

amount to 18 Inches, there would be 8 times as much ; as likewise, if you should suppose it to rise to 20 Inches, there would fall 9 times as much Water upon those Places as flows thro' the Bed of the said River.

SECT. XLIII. *The Method of computing the Quantity of Rain Water falling in a certain Time.*

THE Method which Mr. *Mariotte* makes use of to compute the Quantity of the said Rain-Water, is this ; he took a square Vessel, which, for instance was two Foot in Length, and as much in Breadth, which was raised upon a Horizontal Iron in such a manner that no Water could come into it, but what descended immediately from the Air into the Square of the Orifice thereof. This Water was conveyed by a Tube down into a round Vessel, from whence it would not be Evaporated ; so, that by Gaging the Water in the said round Vessel, it could be known, how high it would have risen from the Bottom of the Square Cistern : And supposing that there fell as much Water in one Year upon one Place, as upon another, one might compute pretty near the Depth of the Rain, that would fall upon the circumjacent Lands in the space of one Year.

SECT. XLIV. *The Rain of Paris compared with that of Lisle.*

Mr. *Mariotte* says farther, that this Experiment having been made at *Dijon*, he found it to amount to 17 Inches ; and another Person that tryed the same, computed it to 19 Inches $2\frac{1}{2}$ Lines. But they that desire to see a very accurate Calculation and Comparifon thereof, may find the same in the *Memoirs of the Royal French Academy*,

1699. p. 25. for 6 Years following, one of which was made by Mr. *Vauban* at *Lisle*; and t'other by Mr. *de la Hire*, at *Paris*; in the following Manner:

Years	<i>Lisle.</i>		<i>Paris.</i>	
	Inches	Lines	Inches	Lines.
1689	18	9	18	11 $\frac{1}{2}$
1690	24	8 $\frac{1}{2}$	23	3 $\frac{1}{4}$
1691	15	2	14	5 $\frac{1}{4}$
1692	25	4 $\frac{1}{2}$	22	7 $\frac{1}{2}$
1693	30	3 $\frac{1}{2}$	22	8
1694	19	3	19	9
	133	6 $\frac{1}{2}$	121	9

And thus the Rain-Water that falls at *Lisle* every Year, amounts to the Heighth of 20 Inches and 3 Lines, as that at *Paris* does to 20 Inches 3 $\frac{1}{2}$ Lines, or at Medium of both 21 Inches.

SECT. XLV. *Rain-Water alone sufficient for Rivers.*

FROM hence, tho' it be plain, that there falls more Rain in one place than in another, within the same Space of Time, yet to make a general middle Computation, it may be safely advanced, that there falls about 20 Inches of Rain yearly upon the Earth, and consequently 9 times as much as was necessary to fill the River *Seine* in one Year. So that, tho' we should deduct from thence all that is serviceable to other Uses, and to the moistening and fertilizing the Ground, and all that Evaporates from it as soon as it is fallen; yet the Rain alone, without the help of other Vapours, furnishes Water enough to maintain a far greater River than the *Seine*; which, if it happen'd in all Places of the

the Globe, and that many of these little Streams should be collected into one great and common Stream, they would together compose mighty Rivers. Accordingly, we find by Experience, that by reason of the Quantity of Waters which they bring with them, famous Rivers are produced by the Concourse of several others that are lesser ; which the Rain-Waters falling upon many great Parts of the Earth discharge therein.

SECT. XLVI. *There is more Water in the Air than what Descends in Rain.*

WE may now infer from the foregoing, that the Vapours which descend in Rain only, seem to be more than sufficient to supply the Rivers ; but that, besides this, the Air does yet abound with a very great Quantity of Waters, may appear :

I. Because those Waters disclose themselves in Mists, Dews, and Nocturnal Moistures, and oftentimes do likewise descend in invisible Vapours.

II. Thus we find in the making of the *Notiometra*, or those Machines by which we measure the Moisture of the Air, as we do the Weight thereof by *Barometers*, and the Warmth by *Thermometers* ; that the Strings of Musical Instruments, Ropes, Wood, and other things, do undergo continual Changes by these Vapours floating in the Air, according as they do more or less abound.

III. The Chymists are particularly sensible thereof, who, when they have reduced their lixivial Salts to pure and true Alcaline, as they call them, with all their Caution, can hardly prevent them from being dissolved by the aforesaid moist Vapours.

And

And I have often thought, when I found good Salt of Tartar within Doors, and in a Laboratory, turned into a clear Liquor, that there must be a very great quantity of these invisible Vapours continually floating in the Air, since, that in so small a Place, in so short a Time, and in so little an Orifice or Mouth, as that of the Glass containing the said Salt, there could be so much Water gather'd together ; for which reason Mr. *de la Hire* himself (*see the Memoirs of the Royal Academy, for 1703. p. 78*) seems to suspect, that Stones likewise, in which there were found any Salts proper to draw Waters to them, might serve to collect the like Vapours into Springs or Rills : At least, the Experiment which he there relates, that even in Places where it don't Rain at all, as in a Cellar, for instance, a considerable quantity of moist Vapours may be found.

V. But this appears yet more plainly from what the said Mr. *de la Hire*, *p. 77.* says farther, that there were a great many Experiments made, by which it was proved, that if you set a very large Vessel with Water in the Air, there will much more Water evaporate out of it than can descend from the Air upon the like Breadth.

SECT. XLVII. *Exhalations from Canals and Ditches.*

To make a rough Guess thereof, a certain curious Miller, whom I asked, How much he thought the Water in the place where his Mill was could be diminished in one Day by the Heat of the Sun? Answer'd me, that in a very warm Day there was (to speak within Bounds) at least the quantity of an Inch in Depth, especially, if the hot Weather continued any time, and by that means his Waters could not be much encreased by those that ran

down from the Lands about him; for otherwise it did not appear to him, that he lost so much Water: But those who have ever seen how much Water is exhaled from the Canals in a very little space of Time, especially when the Ground is dried by a continual Heat, will not judge, that we exceed the Truth, in allowing an Inch a Day in very hot Weather.

For this purpose, in the beginning of *June*, 1710, I filled a flat Earthen Pan with Water, and set it in the open Air in a bright and clear Day, and examining it after four and twenty Hours, I found that there was a full Inch lost in the Depth of it, by Exhalation.

Now, if we suppose, that the Evaporation of all the Waters throughout the whole Earth be equally great, and amounts to an Inch a Day, according to this Calculation, there would be every Year 365 Inches in Depth drawn into the Air: All which, supposing it to fall down again in Rain, would be capable of overflowing the whole Superficies of the Earth 365 Inches high in one Year.

SECT. XLVIII. *Experiments to shew, that Evaporations are likewise performed by Cold.*

LET it not be objected against us, that there cannot be so much Water exhaled under and near the Poles, by reason of the Coldness of those Parts of the World; because,

I. In the very sharpest Frosts, Vapours do continually ascend from our Canals and Ditches, upon breaking the Ice: Now in order to enquire whether this, as some think, might likewise proceed from the Subterraneous Heat; upon the 14th *January* 1709, which, as every Body knows, was a violent and uncommon Frost, I took

an Earthen Bason, and pouring 40 Ounces of Water into it, put it into Scales in a Room where there was no Fire at all made, and found that upon its freezing, it had lost in 17 or 18 Hours, above a quarter of an Ounce in Weight; having taken care to prevent the breaking of the Vessel upon the Waters freezing, by keeping a little Hole in the middle of the Ice always open; thro' which the Water being continually pressed from under the Ice, it made a great Convexity and Protuberance above the Superficies of the said Ice; a sure Sign that Water is both moved and rarified even by Cold. And so before, upon the 8th of *January*, in the same Year, a quantity of Snow being put into the Scales, suffer'd a visible Diminution of its Weight; notwithstanding that it had fallen above three Days before, and lain all the time in the Air; and that which is more, we find even Ice itself will evaporate in the coldest Nights; as has been likewise observed by Mr. Boyle, in his Book, *de Atmospher. Corp. Consist.*

And whilst I am writing this, a Person that has been one and twenty times in *Greenland*, tells me, that when the Weather is Calm, and without Wind, the Sea frequently smoaks and emits a visible Steam, which *Varenius* does also confirm, p. 361, where, speaking of the Seasons in the *Frigid Zone*, he says, that a heavy, foggy and thick Vapour floated over the Water, insomuch, that Peoples Sight was intercepted thereby: From all which it follows, that a great quantity of Vapours ascends from Water in the coldest Regions of the World.

SECT. XLIX. *Objections Answer'd.*

Now if it should be supposed and granted, that the Waters produced by the Exhalations of these Vapours, do not near amount to the quantity of an Inch a Day, as in our warm Climates; we may set against it, that the Heat of the Southern Regions, quite as far as the *Equator*, is much greater than that of ours. And again, that the Superficies of the Earth between us, who lye in about the Latitude of 52 Degrees and the North Pole, is much smaller than that which is between the Parallel inhabited by us, and the *Equator*: Wherefore, the Parts of the Earth, where the Air is much hotter than with us, are incomparably larger than those where it is much colder. So that we shall not seem to have made any great Mistake in taking the quantity of our own Exhalations, or that of an Inch a Day, for a Medium common to the whole Superfices of the Earth.

But, forasmuch as the Terrestrial Globe is not cover'd with Water all round, let us, for greater Certainty, suppose farther, that the Seas, Rivers, and Lakes, do engross no more than half the Superficies thereof: Then the Vapours, that are daily attracted, to the quantity of one Inch in depth, will cover the whole Face of the Earth, when they descend in one Year no more than the half of 365, that is to say, only $182\frac{1}{2}$ Inches deep.

SECT. L. *A Calculation after the rate of an Half-Inch daily Exhalation.*

Now if the daily Exhalation of one Inch should appear too large a Computation, let us suppose it be half as much.

This seems to be the more probable for the following Reasons: *First*, Because Dr. Halley (by keeping a Thermometer with Salt Water continually in that Degree of Warmth in which he had observ'd the Air to be in a hot Day) found upon Trial, and by Weight, that the Superficies of that Water was in the Space of two Hours fallen $\frac{1}{18}$ of an Inch, that is in 12 Hours $\frac{2}{3}$, or in 25 Hours $\frac{3}{4}$ of an Inch, supposing the Exhalation to be always equal.

And again; Forasmuch as the above-mention'd Miller had, at my Request, with great Exactness observed, that from *Tuesday* the 7th of *June*, 1712, to the same Hour the following *Friday* the 10th, the Water in the *Purmer-meer*, or Lake, had lost of its depth $1\frac{1}{2}$ Timber-Inch; that is to say, every Day half an Inch; tho' the Weather was then much cooler than the preceding Days; and he would have proceeded farther in these Observations, if the Weather had not begun to be rainy and windy. After which, the Air being again warmer and calmer, he informed me, that in three other Days there were evaporated two compleat Rynland Inches, which is so much more than half an Inch a Day; and therefore, if we suppose the quantity of Exhalations to amount to no more than half an Inch every Day, and the Superficies of Land and Water to be exactly equal, the Rain that will fall upon the whole Earth, will amount to the half of one $181\frac{1}{2}$, that is about 90 Inches

in Depth ; in case all the Exhalations should fall down again in Rain.

But now Experience teaches us, that the quantity of Rain does not amount to more than about 20 Inches. Wherefore there must be $4\frac{1}{2}$ times as much Water exhaled as descends in Rain ; for $4\frac{1}{2}$ times makes 90. So, that if the Rain be subtracted from thence, there will still remain $3\frac{1}{2}$ times as many Vapours floating in the Air, in order to come down from the Mountains, and to serve for the Uses of Plants and other Necessaries.

So that from hence it may appear in Gross, not only, that besides the Rain there is a large Army of Vapours, of three times as great a quantity, continually floating in the Air, but also a superabundant Number of Exhalations from the Water, which alone rising to the height of 20 Inches, as we have shewn before, yield nine times as much Water as is necessary for the Course of the *Seine*. So that the same being increased to 90 Inches, are adapted to afford above 40 times as much Water as the said River requires.

Wherefore, altho' the Plants stand in need of a great Quantity of Water, and indeed of more than one could imagine, as well as more than all the Rain can supply (as may be seen by the Experiment made by Mr. *de la Hye*, and recited in the *Memoirs of the French Academy*, 1703, p. 73, and 74.) nor could the Rain Water, according to the Observations of that Philosopher, sink deep enough into the Earth ; yet the Mountains, by this Surplus of Vapours, seem adapted to supply and maintain the Rivers.

SECT. LI. *Convictions from the foregoing Observations, and a Word about the Air-Salt.*

NOW to make an end of this Matter ; let the miserable Caviller, who hitherto would not own that there is a GOD that governs the World, seriously reflect upon this astonishing Circulation of so vast a quantity of Waters, which ascending from the Seas, Rivers and Lakes up into the Air, are there preserv'd in Clouds ; and passing a second time thro' the said Air, are made to descend again, partly in the form of Mists, Hail, Snow and otherwise, for various Purposes ; and partly coming down from the Mountains, compose those great Rivers, which again discharging their Waters into the Sea, and from thence again being rais'd up in Vapours, have incessantly, and for the Space of so many Ages, taken the same Course, and thereby supply'd all living Creatures with Drink, fructified the Ground, and render'd innumerable Services to the whole World. And can he still imagine, that it is without a Design, since the whole Ocean, by reason of its Saltness, is entirely useless for these Purposes, that by the Warmth of the Sun (to say nothing here of other Causes which may likewise concur) the Waters of the said Ocean being divided into the minutest Particles in its Ascent, leave all their Salts behind them for other Uses ; which Salts would be prejudicial to most of the Fruits of the Earth, and render the Water useless for quenching Thirst or affording Drink to Animals ; and farther, that the said Water passing thro' the Air in Rain, Dew and other Forms, should impregnate itself with the Salts of the Air and other Parts thereof, in order to become more useful for the aforementioned Purposes ?

Now, whether this Salt of the Air be only Nitrous, as some pretend, we shall not here dispute; but shall take some notice of it hereafter: This is certain, that Salt-petre is likewise produced by the Air, and that the same does contribute, *First*, to the rendering the Water more fructifying, which the Ancient and Modern Gardeners knew well enough, and of which we may see a remarkable Experiment in the Transactions of the *French Academy* 1699, p. 74, and 76. And, *Secondly*, that this same Nitrous-Salt, how much soever it has of the Nature of Salt, is yet a principal Means for extinguishing Thirst, as most Physicians know very well. Let the Atheist consider all this with himself, and see whether he can, with a good Conscience, pretend to reconcile it with mere Chance or Ignorant Causes.

SECT. LII. *The Wonders of the Nile.*

AND now we are speaking of Salt-Petre and of Rivers; can one believe that it is by Chance that the *Nile* in *Egypt*, which overflows and renders the Country fruitful without Rain, carries so much Salt-Petre with it, that a great quantity thereof may be made only by evaporating the Waters of the said River; (*see de Stair Physiologia de Nitro*) insomuch, that this exceeding dry Land becomes so fruitful, as to exceed most of the other Parts of the World. Now if any King or Prince had been so fortunate as to have brought this to pass, and to have found out a Method of watering such a vast Extent of Land every Year with so fructifying a Liquor, and without any Labour of Men, would not this have been recorded to his Praise, as a Wonder of Wisdom, by the latest Posterity? And now that we see this happen in the most glorious Manner, exceeding the Power of the greatest Sovereigns,

reigns, and with so much Advantage, as to preserve the Lives of thousands of Men, and to render this Country, which in its own Nature is one of the most Barren Parts of the World, many times a Magazine and Granary for other Nations, that have been distressed by Famine (as we are informed by History ;) Can any Body satisfy themselves in affirming, that this was done without Design, and by mere Chance? Let such an Infidel or Sceptick only compute how many things must here concur, to render a Country so dry as *Egypt*, and which is never moisten'd with Rain, Fruitful and Plentiful to so high a degree. 1. There must be Water, and in so hot a Country that Water must be brought from some other Parts. 2. For that reason this Country must be lower than almost all the rest of *Africa*, where the *Nile* has its Rise, in order to be over-flowed by that River. 3. And in other Parts it must be higher and more raised, to the end, that during the Inundation People may inhabit there ; and so it is observed to be about the Places where their Towns are built, which at the time of their over-flowing appear like so many Islands. 4. There must be so much Water in order to run over its Banks, and to drown the whole Country. 5. After the Inundation, it must lie a while upon the Ground, to the end, that during its Stagnation, it may deposit the Slime or Mud which it brings along with it. 6. The Water, that it may occasion so great and uncommon Fruitfulness, must be impregnated with a sufficient quantity of Salt-Petre, but not with too much of it ; which does not happen in places where it rains enough, or in any Rivers that I ever heard of. 7. This Water must likewise run off again of itself from the Lands which it over-flow'd, and leave them dry, in order to produce their respective Fruits.

Now

Now, if we should allow that all these Qualities are not peculiar to the *Nile*, forasmuch as we read that the *Indus*, *Ganges*, *Niger*, *Zaire*, and other Rivers, do fertilize also their adjacent Countries by Inundations; will any one infer from thence, that because there is a *GOD* who has exerted his Wisdom, Power and Goodness in more Places than one, therefore He is endowd with none of those Perfections?

SECT. LIII. *Convictions from the foregoing Observations.*

BUT to return from this small Digression, and to shew with how glorious a Lustre infinite Wisdom appears in the Use of Mountains, and the Benefit it communicates to the World by this Circulation of the Waters, and Production of such necessary Rivers; Let a Sceptical Philosopher lay before himself a Map of all the Countries of the World, and attentively view the numerous Rivers therein, which are dispersed throughout like so many rich Fish-Ponds; which, by their Sweet Waters, furnish all things living with Drink; and afford an Opportunity to the most distant Countries mutually to communicate their respective Productions. And let him tell us, whether, if there were no such thing to be found upon the Earth, he would not be obliged to own, with us, that the World would be in a very miserable Condition. And altho' the same quantity of Water were to be met with in some stagnating Lakes and Marshes in the lowest Countries of all, is it not plain, that the higher Regions, at least where it never once Rains, as *Egypt*, *Peru* and the like, would be ruin'd with Droughts. Not to mention, that in a great Collection of Waters, by reason of their stagnating, in process of time, an unavoidable

able Destruction would hang over their Heads. Again, can it be pretended, that it is by mere Chance, that there are such a number of Fountains found in all Parts of the World, out of which at first little Rills and Brooks proceed, which joyn-
ing together, compose great Rivers ; by which means the very driest Countries are furnished with Water, and that with Running and Living Waters too, which, by its continual Motion, is preserv'd from Corruption ? Now this could by no means happen, if there were not Mountains in some low, and even high Countries too, upon which the Vapours being collected, were sufficient to supply Matter for all these Rivers.

SECT. LIV. *The Disposition or Fitness of Mountains for the aforesaid Purposes, and Convictions from thence.*

Now, can this be ascribed to any other Being, than to a Wise, Powerful and Gracious GOD ?

I. That we find such great Bodies as the Mountains distributed throughout the whole Earth.

II. That most of 'em are found in the highest Countries, in order to transmit these Rivers from thence to the Distance of hundreds of Leagues sometimes.

III. That the whole Superficies of the Earth is adapted thereto, which grows gradually lower on all sides where it is washed by the Sea, as is plain from the Course of the Rivers that mostly discharge themselves therein ; since every Body knows that Water, by reason of its Weight, always runs to the lowest Places.

IV. Do we not herein see a wise Direction ? that there are always so many Mountains made for this Purpose, namely, to produce such mighty Rivers as the *Rhine*, the *Danube*, the *Rhone*, the *Borysthenes*,

Borysthenes, &c. (See *Varenius's Geography*, lib. 1. cap. 16. §. 3.) and they that desire to have a larger Account thereof, and to know how the Mountains run in Ridges thro' the Earth, may meet with the same in the said *Varenius*, cap. 10. lib. 1; as also in *Burnett's Theory of the Earth*, cap. 9. who, tho' their Heighth bears very little Proportion to the Bigness of the Globe, is yet of Opinion, that the Space which they take up, may amount to a tenth Part of the solid Land thereof: They that would form a Notion thereof, may consult the Figures which this last Author has made, tho' he uses them to a contrary Purpose, notwithstanding that he has left out several and very large Mountains, on account of the Smallness of his Draught, such as the *Apennin* and other Mountains of *Italy*, &c.

V. Now it seems still necessary, that in the Promontories, or Parts of Lands, running into the Sea, such as *Italy* itself, and others likewise, Mountains are particularly placed for this Purpose, that the Vapours arising from the Sea, should not need to be carried far over Land, before they met with Mountains, where they might be turned into Water and drive down again.

VI. The Islands also seemed, above all the rest, to want Mountains; forasmuch, as being shined upon by the Sun, they were hotter than the Sea-Waters wherewith they are surrounded, and therefore were not likely to receive much Rain thence. To be convinced hereof, let any one view in a Map the aforementioned Islands of *St. Helena*, *St. Thomas*, &c. and consider, whether it be probable, that such little Plains and Spots of Land in Comparison of the circumjacent Seas, and which, for the aforesaid Reasons, does so far exceed them in Heat, could entertain the least Hopes of receiving Water enough from Heaven, if God had not been pleased to provide for them after
so

so particular a manner by the help of Mountains.

Now if any Body that reads the following Passages, taken from the Describers of the World, as first from *Burnet*, *There is no solid Land either of the old or new World, or no old or new Island, but what has its Mountains*. Secondly, from *Varenins*, lib. 1. cap. 10. §. 2. *In most of the Islands, and in Promontaries, the Mountains are scituated, so as to run thro' the middle of 'em, and divide them into two Parts*; which he confirms by many Examples. I say, can he that reads this continue to believe, that it happen'd so by Chance? tho' he is forced to acknowledge, that if a Man were in the highest manner concerned for the Preservation of those Islands, he could not dispose the Mountains therein after a more useful Manner, to make them serve for Watering-Pots to the Country round about them, and for collecting those Vapours, which would otherwise be scatter'd by the Winds, exactly in those Places where they would be most useful. Must not every Body see the Power and Goodness of the great Creator and Governor of all things, shine out most brightly, who, in order to sweeten the Sea-Waters, which of themselves are salt and barren, and to distribute them throughout the Earth where-ever they may be useful, has daily forced Bodies, so considerable in Size and Strength, to contribute thereto; who has order'd the Seas, the Mountains, the Air, the Vapours, the Winds and the Sun itself, that they might perform these great Benefits to the Inhabitants of the Earth, not only to concur in general, but that each of them should likewise afford the most proper and most requisite of all their Faculties; so, that if the Sea had not been sufficient in its utmost Breadth and Depth, if the Mountains had not been high enough, and placed so conveniently; if the Air had

had not been Elastical, and therefore thicker below than above ; if the Vapours had not been light enough ; if the Winds had not been strong enough to drive them along ; if the Sun had not been fixed at so just a Distance, as to yield neither too much nor too little Heat, this great Work of the Circulation of the Waters, and with it almost all Creatures, had long since been at an End, and the whole Terrestrial Globe become a Wilderness.

SECT. LVI. *Rivers require a Place wherein to discharge their Waters.*

HAVING thus far traced the Rivers to their Origin, if me now contemplate their Numbers, their Largeness, and their unconceivable Quantity of Waters, which for so many thousand Years do incessantly pass along with them for the Benefit and Happiness of all that dwell upon the Earth, every one must be convinced of the necessity of very large and deep Spaces where these mighty Streams may rendezvous and meet with such a Receptacle, as to hinder them from over-flowing the dry Ground.

Is it then by Chance, that there are prepared in the Earth such unfathomable Depths, as may contain the whole Ocean, and into which all the Rivers may discharge their Waters, and without which all the Power, and all the Skill, that has been employed in the Frame of the World, and of the Plants and Animals upon it, would be all in vain ?

SECT.

SECT. LVII. *Salt preserves the Sea from Corruption.*

LET now an unhappy Atheist Contemplate with us this great Collection of the Waters, these vastly extended Seas, and say, whether in case the same did consist of nothing but fresh Waters, brought into them by the Rivers and Rains, he can even suppose, that it would have been possible for them, after having been exposed so many Ages to the Action of the Air and Sun, to have been preserved from Corruption and Stinking. Now if that had happen'd, let him consequently consider how grievously the whole Mass of Air, surrounding the Globe of the Earth, would have been infected by such a stinking Lake, and thereby produced innumerable and fatal Diseases. Let him represent to himself in this Case, all the Waters of the Sea so corrupted, that hardly any Fish could live in them. Must not then again mere Chance, or something else, that does not know whether or how it operates, have the Honour of what we are going to say, namely, that just at the bottom of this great Pit, there grows, or is placed, such a quantity of Salt as is capable of converting all the Sweet Waters that run into it into a Pickle, and so to preserve it from Corruption, as well as to hinder the Waters in many Places from freezing, which, if it should happen so easily in the Sea, as it does in Rivers and fresh Waters, it would not only render the Sea many times unpassable, but by stopping Ships in the middle of it, cause an infinite number of People to perish with Hunger?

And yet no Man can shew any Necessity, why there should be such a vast quantity of Salt found in the Sea rather than in other Places, since there
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are likewise Mines and Pits thereof to be met with in many Parts of the Land. Thus we read, that they dig Salt out of the Earth in *Poland*, in *Transylvania*, in *Tyrol*, in *Spain*, in *Lesser Asia*, in *Persia*, and upon the Banks of the *Caspian-Sea*, which last is carried throughout all *Russia*. There is a Mountain of Salt in *Cuba*, and the Island of *Ormous* in the *Persian Gulph*, is said to consist for the most Part of nothing but Salt; in all *Africa* they use such Mineral Salt; in *Peru* there is an unfathomable Mine of it; in the Kingdom of *Masulipatam* in *India* they dig so vast a quantity thereof, that all the *Indians* furnish themselves from thence. See this more largely in *Varenius's Geography*, lib. I. cap. II. §. I.

Can we then, since Salt may justly be reckon'd among the Minerals and Productions of the Earth, ascribe to Accidental and Ignorant Causes, the great Benefit that hereby befalls the whole Earth, namely, that the Sea does also abound in it? Wherefore, if one were to see a quantity of Flesh put into a Vessel of Pickle, by which it is preserved from Putrefaction, would any one say, that the Salt grew there, and that the Flesh was put into it by mere Chance?

SECT. LVIII. *Bays and Gulphs of the Sea for the Reception of Rivers.*

IF this be not enough to shew the Hand of God to unhapy Mortals; yet an Atheist must at least acknowledge, that a great Part of the World would be render'd uninhabitable by the Inundation of Rivers, if the Earth were not washed round about by the great Sea, and which is very wonderful, if the Sea did not transmit great Branches, Arms, or Bays, from itself into the Land, in order (besides other Uses) to receive likewise the discharged

charged Waters of the Rivers into its Bosom, to mix therewith the Great and Salt Sea, and so to yield new Matter for Vapours, and thereby for Rain, and for continuing the Circulation of the said Rivers. From whence it comes, that this whole Structure and great Work would have been still in vain, if the Coasts adjacent to the Sea, and to these Bays and Gulphs, were not lower than the Inland Countries and Regions remote from the Sea. Now shall it be said, that a Matter of such Importance, and upon which the Preservation and Welfare of whole Nations depend, is brought to pass without a wise Design?

To give an Instance thereof: In case the mighty Arm of the Northern Ocean, which is commonly called the *East-Sea*, lying between a great Number of Countries, were not, as one may say, dug out and prepared on purpose to receive likewise all the Rivers that discharge their Waters into it (and which *Varenius* terms, exceeding great ones) how difficult would it have been to them to have found their Way into the Ocean; and how many Provinces would it have render'd uninhabitable by their Inundations, if the Streights of the *Sound*, and those of the *Great and Little Belt*, were stop't, and all the Rivers cease falling into the said *East-Sea*?

The same would happen, if those rich and noble Coasts of that great Gulph which is commonly called the *Mediterranean*, and which Coasts are of so vast an Extent, were not so low, that the Rivers by their weight could run down thither, and from all Parts discharge their mighty Streams, as it were into a Common Drain formed for that Purpose.

For these Reasons it is, that the Passage thro' the *Dardanells* to *Constantinople* is so very difficult, on account of a Current occasion'd by the Dis-

charge of such great Rivers as the *Danube*, the *Nieper* or *Borysthenes*, the *Tanais*, or *Don* and others, which carry their Waters thro' these Streights. See *Robb's Navigation*, p. 84.

Now all these Waters seem to discharge themselves finally into the great Ocean by the Streights of *Gibraltar*; and, as at the *Dardanells*, do there likewise produce a continual Current outwards.

But I was very much surpris'd at what one of the Principal Sea-Officers of *Holland* inform'd me; namely, that having often pass'd the said Streights, besides the known Currents in the *Mediterranean-Sea*, which run Eastwards along the Coast of *Barbary*, and Westward on the opposite Coast, it was experimentally known to all Sea-faring People, that there was a continual Current from the Ocean thro' the said Streight, setting inwards. This they infer, forasmuch as those that will go into the *Mediterranean*, can always pass thro' this Streight by Laveering or Tacking, even tho' the Wind be contrary; and yet, in the same Circumstances, can they pass from the *Mediterranean* into the Ocean, but with much Time and Difficulty.

And when I enquir'd of that Gentleman, what became of that vast quantity of River-Waters which are continually discharged into the *Mediterranean*, and which seem to have no other Outlet but through the aforesaid Streights; he was pleas'd to answer me, that some were of Opinion, that either the Heat of the Sun exhaled those Waters from the Sea, or, as others thought, that there were in the so named *Gulph* of *Narbonne*, or in other Places, some Subterraneous Cavities at the Bottom of the Sea, whereby these Waters were discharged; at least, it was experimentally known, that there is an uncommon Motion of the Sea-Waters

ters in the said Gulph more than in any other Places.

Now, whether this or any thing else be the Cause why the *Mediterranean* Sea, which on the East-side, and all round, does perpetually receive the Waters of such great Rivers, and on the West-side those of the Ocean, has not in so many Ages been so far filled therewith, as not to overflow the adjacent Countries : This is certainly true, that the Divine Providence does herein display itself after a wonderful manner, whereby God has given a convincing and ocular Demonstration, that he will not be bound by any necessary Laws of Nature, but is able to perform all things according to his own Good Pleasure, producing in such a little Corner of the World, as is the distance of the Streights of the *Dardanells* from those of *Gibraltar*, such an amazing Work as the making Place for the Discharge of those mighty Rivers, after two such different and unaccountable Ways. Numberless would be the Wonders that might be produced upon this Occasion from the Natural Histories of the Seas and other Waters : We shall therefore refer our Readers to those that have given Relations and Descriptions of the Sea and Land, all which, if we were to repeat, would be an endless Work.

SECT. LIX. *The Uses of the Sea.*

BUT because we have been large enough upon this Subject, let the Atheist go farther with us, and observe, how the Sea does not only surround the whole Earth, in order, as has been said before, to receive into its Bosom the Rivers and Fresh-waters, and preserve them from Corruption by its Salts, till they become useful again, but likewise, how the said Seas are the only

means by which Commerce and Traffick can be carried on; and each Part of the Globe, that has the advantage of lying near them can enjoy, by the help of Shipping, all the Advantages and Conveniencies of the most Inland Countries. So that the Great Creator has vouchsafed not only to take care of those that lye near the Sea, but likewise of all that live in the very heart of the Continent, by the means of Rivers, and by the imbaying or breaking of the Ocean many Leagues up within the Continents themselves; Instances of which have been given in the East and Mediteradean Seas.

Let us produce another Example; If *Holland*, which has hitherto been so signally blessed by GOD, but which is surrounded with unfruitful Countries and barren Heaths, had been obliged to have fed its Inhabitants with nothing but what itself produced, perhaps there would not have been a more miserable and defective Nation in all *Europe*: Whereas now, by the help of the Sea only, every thing that the old or new World can afford, either for Necessity, Convenience, or Ornament, are brought hither in great abundance. Can then a *Dutch-man* ever look upon the Sea without thinking at the same time, how much he is indebted to Him that made it?

SECT. LX. *The Force of the Sea in bearing Burdens, and Convictions from thence.*

WERE there no Sea, what vast Machines should we stand in need of? What a Strength of an unexpressible Number of Men and Beasts would there be wanting to bring home to us those mighty Burdens which an *Indian* or an East-Country Fleet does now supply? the more because the Merchants must then have been obliged to pass thro' the Coun-

Countries of other People, it may be of Enemies, or of such Nations, who, like the *Arabians*, live upon Plunder; insomuch, that besides the Numbers of Men, they would likewise be forced, for their own Defence, to carry with them great Trains of Artillery, and all other kinds of Ammunition and Provision: Whereas now these heavy Ships, containing all these great Burdens, are so easily born by the Sea, and driven forwards by small blasts of Wind, and very long Voyages performed with much Conveniency and little Time.

If an Atheist should still maintain, that all this is so disposed without any Wisdom, let him contemplate a well equip'd Man of War, or even an *East-India* Ship, and let him be ask'd, what Means could possibly have been invented to have put a Machine of so great a weight as such a Ship, with all its Lading and Cannon, into such a Condition as to cause it to move with a very small Force, without the Assistance of Water, or any other Liquid Matter? The only Answer, if he were a Skilful Mathematician, that he were able to give, would be, that such a Ship must be put into a sufficient Equilibrium, in which case the least Surplus of Weight would be able to move it; just as if it were hanged by a Chain or Rope to a Crane or to one Arm of a Balance, to which there would be a like number of Pounds fasten'd on the other Arm, or after such other manner as a Mechanist could propose to himself; but whereof it is no less certain, that among all the known Matters, none could be found sufficiently strong to serve for Instruments to such Experiments. Much less could they frame any Idea of bringing a Ship from the *Indies* in such a manner.

Now in these Circumstances, if any Man should tell him, that he knew a Way how to carry so

vast a Burden some hundreds of Leagues, and to keep it in a constant Equilibrium, without ever changing its State, so as to be able to move it with a very little Force which way he pleased, according to all the Points of the Compass; wou'd he dare to answer, that such a thing could be performed without a wise Contrivance.

SECT. LXI. *The same Arguments enforced.*

THIS would be the Time to shew the unexpressible Footsteps of an adorable Creator more clearly than at Noon-Day; and to say something of those Laws of the *Hydrostatics*, which are more wonder'd at by every one than as yet understood, in relation to their way of Working; but we shall do this more largely in its proper Place; and we beg those that read it, to apply what we there say, to the Powers of the Sea, to the end, that they may be more fully convinced, even with Astonishment, of the Wisdom and Power of the Great Creator.

To say one word or two of it here; Can one judge, that there is no Knowledge or Contrivance required to raise up one of the greatest Men of War by the help of a few Tuns of Water, which for Weight are by no means comparable to it? And yet it is plain, that this may be done, if such a Ship, drawing 20 Foot of Water, stood upon dry Ground, and that there were made about it a Dock or Sluice of about 21 Foot in Depth, in such manner that there should not remain more than the Breadth of half a Foot, or a good deal less, between the said Ship and Dock. For in case this Interstice between the Ship and the Dock (which being about half a Foot more or less in Breadth, would contain very little Water) were filled up to the Top with Sea-Water, every Body knows, that the aforesaid small quantity of Water being
so

so disposed, would raise up and put into Motion so prodigious a Weight as that of the whole Ship.

This must be ascribed to the Lightness of the Wood alone, as if the Water had but a small share therein : Forasmuch as we hope hereafter experimentally to prove the contrary, when we come to treat about the Laws of the Hydrostatics.

SECT. LXII. *The Fishes of the Sea.*

CAN a Man now that has any thing of Gratitude in him, perswade himself, that he has no Obligations to that GOD, who has surrounded the whole inhabitable Earth with these Waters, and holds them every where in a continual Readiness, that their mighty Strength may be serviceable to Mankind ? If he can, let him go one step farther with us, and contemplate the Depths of the Sea, which in so many Places is unfathomable. It was not sufficient for the Great Creator to preserve the Ocean in such a State, for all the above-mention'd Purposes ; but that this great Space of Waters should not be without further Uses, and to the End, that the Hand of its adorable Maker might be manifested as well by the deepest Cavities as by the vastly extended Superficies thereof, He has been graciously pleased to furnish it with such innumerable Kinds of Fishes, and other Marine Creatures, by the multitude of which so many Men are continually fed ; insomuch, that where no Bread can be procured, but with great Trouble and Charge, the same being dried does likewise supply the Want thereof. Not to mention here the inexpressible variety of Fishes, by which the Appetite and Palates of so many Eaters are gratified ; will an Atheist dare to mention, that the Sea likewise, in this case, with all its Fishes, were made without Design ? Whereas he

himself, and all Land Creatures, could not be able to remain a quarter of an Hour under Water without dying : Is there then no Knowledge required to form so many Creatures after such a manner as to be able not only to live always in the Water ; and as other Creatures find their Support in the Air, they, on the contrary, get their whole Subsistence in the Water ; but likewise bring forth their Young there in so great abundance ? Further, let us consider, how much the Structure of the Eyes of Fishes differ from that of the Land Creatures, the first being adapted only to see in Water, the other in the Air. Let him also consider the Shape and Form of Fishes, where he will plainly discover all those Qualities that are requisite to support them in Water. And since some of them can only live in Salt and others in Sweet-water, let him observe with wonder, that Care is taken for the first by the Sea, and for the last, by Rivers and fresh Inland Waters. And if he desires to be further informed of the Relation which the Fishes and Water have mutually to one another ; let him turn to what is said here below concerning the Fishes, and compare it with this Dissertation about the Sea.

SECT. LXIII. *The Circulation of the Waters does likewise preserve the Land from overflowing.*

To add something farther, which seems to give an irrefragable Proof of a GOD that Rules the Sea to such as are not entirely obdurate ; Can any one see, without the utmost Amazement, that so great, so extended a Space, in which so dreadful a Quantity of Waters is contained, as the Ocean, does not overflow the dry Land, and especially where it is so low as that of *Holland* ; since there is such a Concurrence of Circumstances that seem to render

it unavoidable, unless a greater Power and Wisdom had intervened.

To shew this, let any Man tell us how it is possible, that such an innumerable Company of Rivers, and among them, such great ones as *Varenius* mentions in his Account of Rivers, §. 27. do Day and Night continually discharge into the Sea such an unconceivable Quantity of Waters, and persist therein so many Ages without ceasing, and yet not fill the Sea, nor force it to exceed its Bounds, and overflow the Land.

This would be unintelligible to every one, were it not that all these Waters did constantly observe the Circulation we have shewn before; whereby those Waters that are brought into the Sea by the Rivers, and increase the same, are again attracted by the Heat of the Sun, and do rise up into the Air under the form of Vapours, and there they, or at least some great Part of 'em, are collected upon the Tops of Mountains, or descend again in Rains, and become little Brooks, which, by their Union, compose the same Rivers that carried them into the Sea. Thus performing their continual Circulation from the Land to the Sea, and from the Sea thro' the Air into the Land again.

SECT. LXIV. *The Dykes or Banks of Holland.*

IF any one desires to see a further Proof of the manifest Government and Direction of the Great Creator, let him pass along the Dykes of *North Holland*, and there take notice in how many Places the Waters of the *Zuider-Sea*, are higher than the Lands that lie within the said Dykes. Let him farther contemplate the Smallness of these Dykes, in comparison of the great Extent of Sea, which lies and presses upon them; Let him observe the amazing Power and Strength of the Sea, by which,
tho'

tho' cover'd with Ships, it so easily bears the unexpressible Burden, and upon the least stirring of its Waves, can move and lift them up. Would he, if he did not know those Laws to which the Great Ruler has subjected these watry Desarts, would he not consider it as a continual and unconceivable Miracle, that those Dykes, so small and slender in respect to the Waters that press upon them, have not long since been overturned and carried away by the weight thereof, and the adjacent Land turned into Sea: At least, it appears from hence, that there is need of more than humane Assistance to preserve such a Country from Inundations.

For instance; Let us suppose A B (*Tab. XV. Fig. 2.*) to be the Breadth or Extent of the aforesaid *Zuider-Sea*, and if you please too, cover'd with Ships, which, by their prodigious weight, do press the Waters forward on all Sides; Let A C and B D, be the Dykes (which we only represent here in their height by a Line) which hinder the Water from overflowing the Lands I K, that lie behind them. Now if one draws the Line C B, 'tis plain, that all the Waters at A C B, would press against the Dyke A C; in case the Waters observed the same Laws in gravitating as solid Bodies do. Now, let any one propose to himself, that this whole Body A B C, were cover'd with Wood, and the whole Superficies thereof, A B, with tall and well-equip'd Ships, instead of Water, as has been here supposed. Now, if this great and heavy Body could slide downwards so smoothly, and without any Friction or Resistance, along the Oblique line B C, as the Water can do, and could press after the same manner upon the Dyke A C, one need not ask, whether the Dyke could stand against it only one Hour. Now, since Water is uncontestably heavier than Wood, 'tis plain, that the still-standing Sea would act with
greater

greater Violence against the said Dyke than the Wood A B C ; in case the Water should operate according to its Weight, after the same manner as the said Great Body : The Consequence of which would be, that no Land in the World, which lay lower than the Sea, could be defended against it by any Dykes.

To account for this Difficulty in some measure here (since we shall speak more fully of it hereafter in its proper Place) is it without Wisdom, that the whole Sea A B C D (*Tab. XV. Fig. 2.*) cover'd with this vast weight of so many great Ships, and of the breadth of so many Leagues, does not press stronger against the Dyke A C, than the small but equally deep Ditch A E, would do, which is no broader than a Rod, and a good deal less ?

Wherefore, tho' the Dyke A C, consisted only of thin Glass, the whole Sea A B C D, would not be able to break it with all its Pressure, if there were only behind the said Dyke at G H C A, a little Water, no broader than a Foot at G A, but of equal Depth of the Sea.

Now, that this is true, they that understand the Hydrostatics know very well, we shall also shew it more largely hereafter. And the same is the only Cause, why the whole Sea, cover'd with Thousands of Ships, if it be calm and not too deep (since it is by the Depth only, and not the Breadth, that its Powers are increased) is often bridled by a slight Dyke, and prevented from overflowing so many Countries, and drowning Men and Beasts.

SECT. LXV. *Sand stops the Sea, and proceeds from it.*

BUT now, if any one goes farther, and has ever contemplated this dreadful Abyſs in its wild Motions, when excited by Storms, or its Waves riſing to incredible Heights, and threatening to inundate and ſwallow the dry Land : Could he then think it were by Chance, that the mad Waves of this terrible Heap of Waters are to this Day contained within its Bounds ? And he that has ever ſeriously and earneſtly reflected upon the whole, muſt he not entirely juſtify the Diſcourſe of the Great Creator of all Things, when he ſharply Reproaches the Careleſs *Iſraelites* of their Blindneſs and Dullneſs, in the following manner, by the Prophet *Jeremiah*, c. v. ver. 21, 22. *Hear now this, O fooliſh People, and without underſtanding, which have Eyes and ſee not, which have Ears and hear not, fear ye not me ? ſaith the Lord : Will ye not tremble at my Preſence, which have placed the Sand for the Bound of the Sea, by a perpetual Decree that it cannot paſs it ; and tho' the Waves thereof toſs themſelves, yet can they not prevail ; tho' they roar, yet can they not paſs over it.*

Shew any one, that has ſeen a ſtormy Sea rolling its Waves in its full Courſe, a handful of Sand, and tell him, that ſo ſmall, ſo contemptible Bodies, which one may blow away with ones Mouth, can reſtrain the Rage of ſuch watry Mountains ; would he not look upon it as a Wonder ? But tell him, moreover, that the Sea itſelf does, according to all probability, produce that Sand, and thereby becomes itſelf a Bridle to its own fearful Powers ; according to the above-mention'd Experiment of *Meſſieurs Hook and Plot*, where it is ſhewn, that by the Evaporation of Salt-Water (which is continually

tinually performed by the Heat of the Sun upon the Sea) a great Quantity of Sand is produced. Can he likewise think, that a blind and ignorant Nature has bestowed this Property upon the Salt-Water of the Sea, and thereby only preserved such flourishing Kingdoms and so many Provinces from Inundations, with casting up whole Mountains of Sand out of the Sea in Places, that otherwise, by reason of their Flatness and Lowness, might daily expect to be swallowed up? Can he look upon the double Sand-banks placed along the Coasts, which are like so many Walls and Bulwarks against the Incurſion of this all-destroying Sea-Enemy? Can he observe the oblique Ascent of the Shoar, in order to break the Force of the Sea, or the Heighth of the Downs that lie behind, without being obliged to own, that a Great and Adorable Engineer has vouchsafed thereby to fortify this Country against an Invader, powerful beyond Conception, and which assaults them continually? The rather, because one cannot imagine how it should be possible, that such loose Heaps of Sands are not entirely scatter'd by the Winds, when we see so often such great Quantities thereof raised up and carried thro' the Air. Again, will any one say, that it is by mere Chance, that in these dry and barren Sands (which otherwise are hardly capable to produce any Plant) certain Herbs or Weeds do not only grow, but are likewise proper to be transplanted, by the means of which these Sand-banks are defended against the scattering Winds, and the Downs brought and continued in their Places where they can be most serviceable?

SECT. LXVI. *The Sea-Weed the support of Dykes.*

IN other Places, where the Sand is not in so great Plenty, as in the *Zuider-Sea*, which is supposed to be formed by an Inundation from the Ocean, and which is only bounded by Dykes; Experience shews, that no better can be found for the making thereof, than that Sea Weed which we call *Wier*. Now can any Body imagine, that the *Hollanders*, in this Case, speak without Reason or Grounds, when they fetch from thence a Proof of a GOD that preserves their Country? Forasmuch as they see, that this Weed is produced even by the Sea, in great abundance, and the Dykes thereof are maintained by it.

SECT. LXVII. *The English Channel preserves Holland.*

YET more; Forasmuch as all this does hardly seem sufficient to secure our Low-Countries from being buried under the Waters of the great Ocean, can any one imagine, that it is ordered by Chance that the Promontary of *France*, and that Great and Noble Island of *Britain* makes between 'em a Streight or Channel, which is broad enough for a Fleet of Ships to pass thro', and yet narrow enough to hinder this dreadful Ocean, when it ascends in its Flux, from discharging with full Strength his watry Mountains upon the Coast of *Holland*: Since either by wanting too much Time to pass thro' the Channel, it is carried back by a seasonable Ebbing, or, as others think, because the North-Sea growing continually wider on this Side, the Waters that flow thro' the Channel cannot continue at such a height. Accordingly, Experience

rience teaches us, that for this last Reason the Tide of Flood runs five or six times as high at *Calis* as in the *North-Sea* ; which is observed by Mr. *Hartsoeker*, in his Treatise of Natural Philosophy.

SECT. LXVIII. *The Cause of Ebbing and Flowing omitted.*

WE shall pass by the famous and great Motion of the Sea in its Flux and Reflux, or Ebbing and Flowing, as well as others that are not less wonderful ; forasmuch, as the Causes thereof seem to be kept among the inscrutable Secrets of the Creator ; referring those, that desire farther Informations, to the Opinion of the great Naturalists, some of which seem to carry along with them a great deal of probability.

This is certain, that the Waters of the Sea, under the Moon or thereabouts, do on either side of the Globe raise an exceeding great and convex Mountain, which daily surrounds the Earth. Now, that this cannot happen without disturbing the Sea, even in its deepest Cavities and Abysses, is plain enough.

Mr. *Mariotte* has shewn (in his Book *Du Movement des Eaux*, p. 217, &c.) experimentally, that in running Waters, unless some particular Occasion intervenes, the Water at or near the upper Superficies, runs much swifter than that in the middle, or at the bottom ; for which reason, in great Depths of the Sea, notwithstanding the Currents and Motions that may prevail at Top, it is credible, that the lowest Waters are quite still or move but very little ; so that the same having stagnated for so many Ages, might easily be corrupted.

Now,

Now, whether the Great Ruler does not likewise make use of those Motions and Tossing of the Waves, to preserve the Sea-Water from Corruption, even to the very Bottom of them, to keep the Fishes and other Creatures alive, and the Air it self pure and sweet, which might otherwise be infected thereby, we leave to the Judgment of the Learned : At least 'tis well enough known, how very useful the Flowing and Ebbing of the Sea is to Mariners, particularly, when they sail out or into their Havens, where otherwise there might be great Danger. You will see below, in *Contemplation XXV.* something more relating to this great Phænomenon.

SECT. LXIX. *Water bestowed in such great abundance, and for so many Ages gratis, to Living Creatures.*

BEFORE we quite leave this Subject, let us in the last place beseech all unhappy Philosophers, seriously to consider, that this Water, which brings along with it so great and so many Advantages, is to be found in such great Plenty, and to be procured by those that want it, almost in all Places, for nothing. Cannot we see herein the Goodness of the Giver ! And he that knows not how sufficiently to value the Benefit, let him only represent to himself the exceeding Trouble and Concern that all Men are in when they apprehend a Scarcity thereof, as it happens sometimes in Besieged Towns, and to the Ships Company in a long Voyage. But besides this, does not the Wisdom of a Divine Direction appear herein, that this Water is always abounding, and never fails, notwithstanding that we might so justly fear, that considering all the Occasions whereby the Water may

may be either lessen'd or corrupted, every Living Creature would perish with Thirst?

How many Years, yea, Ages, has this Water been moved by the Winds? been rolled along hard Beds? dashed against Rocks? used in extinguishing Fires? served for Drink to so many Creatures? drawn up into the Clouds? fallen down into Rains, and by reason of its Weight, driven violently down Walls, Houses, Mountains, Rocks, and other hard Bodies? been congealed into Ice, Hail and Snow? And finally been moved and handled in the roughest Manner by different Powers? And may not every one then, with great probability, suppose, that the Water, after having undergone all that is above-mention'd, for so many thousand Years, should be worn out and have changed its Figure, or, which is the same thing, its Properties. So, that any Body, who knows how much all things are worn by a continual Use, by which they are certainly render'd less fit for Motion, could hardly be induced to believe, that one and the same Substance, after having withstood so many and so great Shocks, between five and six Thousand Years, should be able to preserve the same Figure. Notwithstanding which, we are taught by daily Experience, that the Waters of the Sea, of Rivers, and of Rains, have remain'd always Unchanged; and preserv'd their Nature and Properties. Can we not then observe herein a Government, a Providence, not only surpassing all Humane Power, but even all Opinions and Arguments? And is not the mighty Hand of a Great Preserver visible enough to all that will consider this without Prejudice?

Now if any Body should object against this, that Waters, as well as all other Substances, does undergo an Attrition; but, that there is continually as much new Water produced by other Causes, as

that which is worn away and otherwise wasted ; yet that won't lessen the Wonder, nor in the least enervate this Proof. For if it be allowed, will there then be no want of a wise and powerful Direction to substitute continually an equal Quantity of Water, to that which is lost by Attrition, and without which the whole Earth would fall into Disorder ? And can any Body, upon such an Hypothesis, pretend, that it comes to pass by Chance or Ignorant Causes, that there is just as much Water produced as was worn away, or consumed, by the various Uses thereof ? Why then is not there more produced than was lost ? And why are not the Rivers, in so many thousand Years, increased to such a degree as to overflow the most Part of the dry Land ? Or on the other Side, why is not the Water diminished ? Why is not there more corrupted or wasted, than is reproduced ? And why are not the Seas, and all the Collections of Waters, evaporatd or dried up in so many Ages ? Moreover, in case the Particles of Water were any wise Angular or Oval, why are they not become quite round, by a perpetual Attrition against each other for so long a time ? That being the last Figure assumed by most Bodies after the Attrition of their Angles. And if these Particles are Globular, why are they not entirely crumbled to Atoms by this incessant rubbing, and wearing, and striking against each other, or as some Philosophers fancy, turn thereby into the Substance of Fire ? At least, if the Essence of Water consists in a determinate Figure of its Parts, how can such an Attrition happen without any Change in its Properties at the same time that the Figure thereof is changed ? And why is not Water, for these Reasons, represented to us now under a quite different Appearance from what it was several Ages ago ? If we now add to what has been already said, and if we consider

Consider how much Water (according to the above-mention'd Experiment of Mr. Boyle) can and will be turned into Earth by a continual Distillation of the Sun, and of the Subterraneous Fires; how much is fixed and incorporated with, or converted into thousands of Plants; how much is used in the Composition of the Bodies and Humours of such an infinite Number of Creatures; might we not with great Reason judge, that this continuing for thousands of Years, and the great number of Things which are composed of Water in a great measure, being likewise consider'd, it must have been long since exceedingly diminished if it had not quite failed. Nevertheless, we see, that this Water remains in the Quantity that is necessary for all our Uses.



CONTEMPLATION XIX.

Of the EARTH.

SECT. I. *Transition to the EARTH.*

NOW, if after having Contemplated the Air and the Water, we pass on to the EARTH, we cannot help affirming, that whosoever shall maintain that all the Qualities and Properties that are to be found therein, are to be only ascribed to mere Chance, or ignorant Laws of Nature operating without Design, must cleave to a wonderful kind of Philosophy, if he does not affirm the same against the Contradictions of his own Conscience.

It is true, that the Earth, as such, and so long as it remains in its Natural State, cannot serve either for Meat or Drink to Men and Beasts; but however, that every thing Living is supported and preserved by its Fruits, is plainly taught us by Experience.

SECT. II. *The Earth produces Grass, Corn, &c.*

LET an Atheist, to fetch no Proofs from the Depths of Nature, cast his Eyes, *First*, upon that common Herb, that contemptible Grass which springs so abundantly out of the Earth and feeds such a number of Cattle: And *Secondly*, upon the various Kinds of Corn, whereby such Numbers of Men are likewise supported; and then let him consider with himself, whether it be by Chance that the first grows of its own accord out of the Earth in such an infinite Number of Places, and serves for Provision to the Cattle. And in case there were not such a Disposition in the Earth, that it produces Grass in so vast a Quantity almost every where, without the least Labour, or without any Cultivation, what possible Means could have been invented for the nourishing and preserving alive, so many Millions of Living Creatures, which in themselves have not the least Fitness for Tilling and Sowing the Earth?

SECT. III. *Beasts are Kitchens for the Grass.*

FURTHERMORE, since he cannot deny neither, that tho' the whole World were full of Grass, yet all Mankind might perish with Hunger, since sad Experience has frequently taught us, in Barren Years, that no Body can live of Grass; will he again say, that this is likewise Accidental, and without a wise Direction, that the Earth is adapted

to produce Corn and other Things, which serve Mankind for Food? And since Grass of itself is not fit for that purpose, that by being eaten of Beasts, it should be changed into their own Substance, and so become useful not only for Food, but even for Dainties too: Insomuch, that we may look upon Oxen, Sheep and all other Creatures, that are taken by Men for Food, as so many living and walking Kitchens; in which is prepared the otherwise unprofitable Grass, and becomes good, wholesome and palatable Food.

SECT. IV. *Convictions from the foregoing Observations.*

AND whereas the greatest Philosopher, with all his Wisdom, cannot produce one single Grain of Wheat, or the smallest Leaf of Grass out of the Earth, nor even inform us with Truth, how they grow and subsist; and much less, what is the Cause, that Grass serves for Food to the Cattle, and yet can nourish no Man before it becomes Milk or Flesh by the Changes it undergoes in their Bodies; Can he then persist in such an Opinion, that it is without any Design, or Knowledge, of a Providential Being, that there is this analogy found in Beasts and Grass, in Men and Corn, by which both are supported; and that it is one and the same Earth which produces them both?

If this can be maintained, I dont see why one may not say, with as great an Appearance of Reason, that a Lock and the Key that is made and adapted to it, are both of 'em produced by the same Iron, without Understanding and without Design.

Let those that would make use of such Evasions, consider only how many other sort of Herbs daily come out of the Earth; and since there are pro-

duced Thorns and Thistles (to say nothing of Poisonous Herbs) as well as Fodder for Beasts, and Bread for Men ; let him shew us the least reason, why the first, namely Grass, grows almost every where without any Trouble even in the most Solitary Wilderesses, where it feeds Harts and Hinds, and other Grass-eating Creatures, in great abundance ; whereas, on the Contrary, to produce Corn and humane Food from the Earth, there is required so much Plowing, Harrowing, Sowing, Weeding, Mowing, and so much other painful Toiling ?

This has frequently put me in mind of the Accomplishment of that Threat which GOD pronounced to Man, at the beginning of the World ; *Gen. iii. 17, 18, 19. Unto Adam he said, because thou hast harken'd unto the voice of thy Wife, and hast eaten of the Tree of which I commanded thee, saying, Thou shalt not eat of it : Cursed is the Ground for thy sake ; in sorrow shalt thou eat of it all the days of thy Life. Thorns also and Thistles shall it bring forth to thee : and thou shalt eat the Herb of the Field. In the sweat of thy Face shalt thou eat Bread till thou return unto the Ground ; for out of it wast thou taken ; for dust thou art, and unto dust shalt thou return.* Now, all this is true by sad Experience, by which we are taught how much Pains are required to clear the Ground from Thorns and Thistles, that it may be fitted for the Support of Mankind.

SECT. V. *Different Productions and Powers from the same Earth.*

STRONGER Demonstrations of a wise and gracious GOD, no Man can justly require, than that which the Earth may teach every one who Contemplates the Properties thereof. Nor is there

there any deep Philosophy necessary for such Convictions.

Bring a Man only into Meadows where the Grass springs out of the Earth for the Cattle ; or into plowed Lands, where the Corn grows for Mankind ; into Gardens where one sees such noble and refreshing Fruits ; into Woods, where he finds innumerable Trees which furnish Materials for Building ; into Physick Gardens, where he finds a number of Plants and Herbs, some of which serve for Food, others for Medicines in the Disorders and Distempers of our Bodies, and for other Uses ; into Flower-Gardens, where there appears an infinite Quantity of the most charming Colours and Smells of various Powers and Effects. Then ask him, Whether he or any Body else, ever understood the Manner by which all this is produced in the Earth ; and, whether those can be thought to argue so improperly who maintain, that all this seems to them one continual Miracle and Demonstration of a terrible, but no less bountiful GOD, who, from one and the same Earth, is able to produce such an unconceivable variety of Plants. Let them freely maintain, pursuant to late Discoveries and Experiments, that there are Seeds, Plants and Stamina, in all Seeds and Budds, which are expanded and augmented by additional Juices : But how will he be able to deduce the Diversity of Powers from the same Earth, after such a manner as may give entire Satisfaction to the Learned ?

SECT. VI. *Convictions from the foregoing Observations.*

NOW if there should be shewn to one of these unhappy Philosophers, who had never seen any Earth, a piece of black and uncomely Matter, would he not, upon Contemplating all the before-mention'd Operations and Effects, take it for one of the most wonderful things in the World? And further, if some Body that were the only Possessor of this Earth, should declare, that he had thus disposed it by his Wisdom, and would generously present him with a small Parcel thereof, would he not reckon this noble Gift among his most valuable Rarities, and shew it to other curious Persons as a very precious Thing? And if it should so happen, that one of those to whom he should shew it, should say, that he did not think the Person that had prepared it to be Wise or Knowing; and, that altho' he had made such a Mixture, it could not be ascribed to his Skill or Judgment, but only by mere Chance, or some other Ignorant Cause; would not even this Philosopher declare, that great wrong and injustice was done to the Maker of such a Prolifick Matter; and that from the Aptitude and Property which this Earth has to produce so great a Diversity of Plants, an irrefragable Proof may be drawn, that he who invented and compounded such a Mixture, must have had; not only a particular knowledge thereof, but likewise of all the Herbs and Plants which such a Matter produced; and consequently must be wiser than Thousands of other Men, who, how learned soever they may be, if once the Earth should fail, could never inform us whereof it properly consisted, and wherein lay its Power or Faculty to produce all Sorts of Plants.

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Let a deplorable Atheist himself make the further Application to what has been said. And forasmuch as he will find that this Earth is disposed in so great an abundance, and for the service of all Men throughout the whole inhabitable World; far from being any Want or Defect thereof, this noble miraculous Matter is trod under Foot by Men and Beasts, and serves for Ways to Travelers: And whereas we should have acknowledged an unconceivable Wisdom in the Preparation and Disposition thereof, if there had been but a very small Quantity of it in the World; Shall we now doubt of the Wisdom and Goodness of the Great Creator, only because he has been so bountiful and liberal thereof, and has communicated this wonderful Gift in so great an abundance to Mankind.

To say a little more upon the same Subject: Whereas every one would stand amaz'd if he had seen but one Tulip, one Rose, or one Lily, only growing out of such Contemptible Matter as the Earth appears to be, and could never be tired in praising the Wisdom of Him who had found out the way of producing those noble Flowers; shall we therefore now be more backward in acknowledging the Great Creator in his Perfections, because instead of disclosing to us one Wonder in one Plant, we daily discover a thousand Wonders in as many Plants.

SECT. VII. *Earth is never consumed, nor becomes entirely barren.*

WHEREAS now this Earth feeds every Creature, such as Men in all Places; the Cattle in Meadows and Stalls; the wild Beasts in Woods and Defarts; Birds, Fishes; all sorts of Insects and creeping Creatures, such as Worms, Catterpillars, Flyes, &c.; in a word, every Thing that has

Life ; for altho' some of them may make use of others for their Food, yet those that serve for Food to others, are themselves nourished by the Fruits of the Earth. Moreover, whereas this Earth does daily bring forth from its Bowels an infinite number of Herbs, Flowers, Plants, Shrubs and Trees, for such various Purposes, and has done the same for so many thousand Years ; can any one without astonishment reflect, that since so much Earth has been made use of to the said Purposes for so many Ages, yet in so great a Series of Time it has never failed, nor entirely lost its Fecundity ? For that otherwise the Fruitfulness of the Earth is lessen'd by the continual use of it, is well known to those who have seen the same come to pass in Land frequently sown, more often than they are willing.

SECT. VIII. *An Experiment to shew, that Air makes the Earth Fruitful.*

Ask now these Philosophers, so wise in their own Conceit, how they pretend to avoid these Mischiefs, which seem impossible to be obviated ; and so to preserve themselves and all other Creatures from certain Death ? And tho' some of these should acknowledge on any other account, yet, can he think that it happens without Wisdom and a determinate Purpose, that the Earth, which having lost its Fecundity by too long an use, is rained upon from the Clouds, and by being only turned up several times, and exposed to the influence of the Air, recovers the said Fecundity again ? What is otherwise laying the Land Fallow, than turning frequently the Parts of it upside down, and so affording an occasion to the Air to fructifie the same ? Now, whether this happens by the means of a Nitrous Salt, which is so much extolled

toll'd by all the Gardeners on account of its Fertilizing Powers, and which is produced in the Earth by the Air, we shall not here dispute. But the matter of Fact has been experienced by me several Years ago, namely, that the barren Earth, of a Garden, that had been long sowed, lying Fallow for a Year, and having been frequently broke into small Pieces, caus'd the Seed with which it was sown the following Year, to grow very thick and strong, without using Dung or any thing else to it, that we might be most certain of the Tryal.

SECT. IX. *Convictions from thence.*

Now if a Man would but only consider these Methods of Fertilizing the Ground, and afterwards earnestly weigh the following Particulars: *First*, That Air and Rain have the necessary Faculties of being subservient to this Purpose. *Secondly*, That this is frequently performed by both of 'em, without the concurrence of any Human Labour or Pains. *Thirdly*, That hereby the Earth in Woods and Desarts, remains in a Condition, tho' uncultivated, to supply the wild Beasts feeding therein with sufficient Fodder. I say, after having understood all this, can he accuse another of Stupidity, who should with Reverence acknowledge the Goodness of the great Supporter and Provider of all Creatures, because he will not suppose, without Reason, as he himself does, that all this comes to pass by Chance, and that no Wisdom has been here used, or need to have been, to impart to the Air, to the Rain, to the Earth, to the Beasts, all the requisite and particular Qualities, by a particular renewed Fertility of the one, to afford a constant Support to the other?

SECT. X. *It should seem as if the Earth would be render'd Loathsome, by Filth and Nastiness.*

IF all this be not sufficient to make a deplorable Atheist observe the Finger of GOD; let him tell us himself, whether he could have order'd the Structure of the Earth and of the things that are produced from it with greater Wisdom than that which he now sees, at least he cannot deny but that,

I. All Plants, Men and Beasts, proceed from the Earth; the first is plain in itself; and to prove it of the last, are not all Living Creatures formed of the Fluids or Juices of those that procreate them, or at least expanded and rolled out to their respective Magnitudes? Do not these Juices proceed from their Food? the Food from Herbs and Plants? and these from the Earth? So that a continual Experience teaches us the same. Even Creatures that stand in need of Cloaths and Covering, receive it only from the Earth; the Wooll of Sheep, the Skins of Beasts, Flax, the Leaves and Barks of Trees, do all proceed from the Earth.

II. That nothing is everlasting; and that every thing living undergoes a kind of Death, and thereby is abandon'd to Stench and Corruption, is no less certain than the foregoing. So that every thing, when it has served the Purposes for which it was made, seems to be nothing more afterwards but an useless and loathsome Ballast of the World, and to render the most agreeable Places (where Numbers of Men and Beasts do reside) deserted and uninhabitable by the Stench of so many dead Bodies and Carkasses.

III. That

III. That (to speak only of Living Creatures) all the Meat with which they are fed, is converted in their Bowels to a loathsome Dung and Excrement, can be denied by no Body. Now if all that has ever been thus discharged by so many living Creatures as have been upon the Earth in so many Ages, and should so remain in its disagreeable Form and Qualities without any Change, must it not be confessed, that it would have been sufficient to render the whole Earth and the Air surrounding it, exceeding nauseous and loathsome to the Inhabitants?

IV. Add hereto, that so many Millions of Men and Beasts, that do only consist of the Productions of the Earth, have been so many Ages in the World, that it would not have been possible, without the intervening Care of a superior Wisdom, but that the Fruitful Earth would have been very much diminished and consumed: So that altho' this Globe had no Destruction to apprehend otherwise, yet every thing that lived upon it would finally perish by the failure of the Earth's Fertility, and consequently of Food.

SECT. XI. *This Loathsomeness prevented, and Convictions from thence.*

Ask now an Atheist, whether he could sufficiently praise the Wisdom of such a one as had found out a Method to prevent all these nauseous and loathsome Inconveniencies? And if he himself could have done it, or could have taught Mankind the way whereby all Corrupted Plants, all the Carcasses of Men and Beasts, in a Word, all other putrified Bodies could be converted to a most profitable Matter, and to a most fruitful Earth, and even to such a one as should be capable of restoring Lands, that were quite worn out and spent, to their

their former Fertility ; I say, if he himself could have found out such a Way, would he not think that he had laid a perpetual Obligation upon all Mankind ?

Now this is what we daily see come to pass, and that without any Pains and Trouble on our Part.

SECT. XII. *The Circulation of almost all things from Earth to Earth ; and Convictions from thence.*

CAN it be then thought that such ingeniously contrived Bodies of Men, of Beasts, and of Plants, proceed all from the Earth, without the Concurrence of a great Director ? and having appeared in such Forms after a little while are turned to Earth again, which brings forth more that are likewise to undergo the same Fate. And can an Atheist be so void of all Reason, as to conceive, that such a wonderful Circulation and Revolution of Things, during so many Ages, can come to pass without a wise Direction ? Whereas, if he were required to perform the least thing analogous thereto by his Wisdom, he would be forced to confess, that his Understanding did not extend itself near so far.

SECT. XIII. *Several Texts of Scripture proving the same, and Convictions from the Whole.*

THE Wisdom of the Almighty in his Holy Word has often plainly occur'd to me, in which this unconceivable Circulation of Things, from Earth to Earth again, is mention'd with great Energy. We shall not now speak of the first Production of all Things, according to which, Grass, Herbs and Trees, *Gen. i. 11, 12.* Living Creatures, *ver. 24, 25.* and *Gen. ii. 7.* Man was formed from the Earth : Since this was done in a particu-

lar

lar and unintelligible manner; but only observe from thence, that an Infidel has not so much reason to look upon any thing mention'd in this Chapter as impossible, forasmuch as we are taught by Experience, even now, that all these things come out of the Earth; and that what we daily see with our Eyes, does differ at most only in the manner from what is there related by *Moses*.

Now it is very credible, that an Atheist, by whom the manner how this was brought to pass has never been comprehended, would not make less Difficulty in admitting, that all these things proceeded from Earth, now at this time, if any one assured him of the Truth of it, than he does, that it was so in the beginning, upon the Words of *Moses*. From whence certainly appears with how little Ground these unhappy Men contradict Divine Revelation, only upon the Head that they don't understand it. And this their Blindness is so much the more to be pitied, forasmuch, as if they only attended to Modern Experience, they would necessarily be of another Opinion, and acknowledge, that there daily happens before their Eyes something analogous to that which their Creator assured 'em of in the foregoing Text of *Genesis*, but which they would not believe upon his Word.

To illustrate the foregoing with other very plain Texts; could *Solomon* speak otherwise than he does, about the Production of all things from Earth, and their return to the same, in *Eccles. iii. 20*? *All go into one place, all are of Dust, and all return to Dust again.* And in Chap. xii. 7. in the following Words; *Then shall the Dust return to Earth as it was*; where he calls Human Bodies (because they proceed from Earth, and after Death are turned into it again) even by the name of Dust. At the same time acknowledging, that that which the great *Jehovah* had said to the first Man, *Gen. iii. 19. Till thou re-*
turn

unto the Ground ; for out of it wast thou taken ; for Dust thou art, and unto Dust shalt thou return, appeared even in his time to a diligent Observer, to remain in the full Force of Truth. So likewise the Composer of the 104 *Psalms*, counting this among the Wonders of the most High, in *ver.* 29. where speaking of Men, Beasts and Fishes, he says ; *Thou hidest thy Face, they are troubled, thou takest away their Breath, they dye, and return to their Dust. Thou sendest forth thy Spirit, they are Created ; and thou renewest the Face of the Earth.* Several other Places might be here quoted from the holy Scriptures, in which mention is made of Things being turned to Earth, which we shall now pass by ; only adding this brief Remark, that the great Inspirer of this Word does not only point at the returning to Earth, but even to Dung also. Thus it is said in *Jeremiah*, *xvi.* 4. and *xxv.* and *xxxiii.* of Slain Men ; and on *Ch.* *viii.* *v.* 2. even of their Bones too ; *that they should be for Dung upon the Face of the Earth.* And again, in *Isaiah*, *ch.* *li.* *v.* 12. *Who art thou, that thou shouldest be afraid of a Man that shall dye, and of the Son of Man, which shall be made as Grass.*

SECT. XIV. *An Experiment about Distilled Earth.*

Now as wonderful as the Matter of Earth has been shewn to be, yet has it been but very slightly examined in the preceding Ages ; and tho' in the very last of all the Science of Nature, was more promoted than in several of the former ; yet the knowledge of the true Properties of the fruitful Earth does still remain very obscure. Now, that in so learned an Age the Enquiry into Nature should be wholly neglected, is not to be supposed ; for which reason, perhaps, the Difficulty of saying any thing concerning it upon sure Grounds, may be the Cause that so little is writ about it.

To say something of its common Origin ; That the Earth can be produced from Water has been shewn before, when we treated of the Latter ; and it appears, from *Boyle's* Experiment, how Water, by a continual Distillation, is turned into a certain Earth. But to say something particularly about Fruitful Earth ; many Plants (as has been more largely shewn in the foregoing *Contemplation*, §. IV.) grow out of Water, which Plants, being corrupted or rotten, yeild a fruitful Earth ; in a word, this is confirmed by daily Experience, namely, that all Beasts and Plants may be converted into a Fruitful Earth.

We shall forbear to deduce any general Hypothesis from hence ; since we have not yet made sufficient Discoveries upon which to found any certain Opinion ; and we are not ashamed to own, with many others, that we do not fully know from whence and how Earth is produced : And that the Modern Experiments, tho' they show us many things, are not yet capable of imparting to us the right Knowledge of all that ought to be comprehended upon this Subject.

Now, since the Nature itself of the Fruitful Earth, seems to have been but little enquired into as yet ; I procured from an accurate Florist, one sort of such an Earth (for that there are several is plain from Experience ;) this Earth was composed of Cow and Horse Dung, mingled with Sand, and had been cleared from Stones by Sifting ; I distilled it in a Glass Retort, and found that it yielded a Liquor, which being mingled with the Acid Spirit of Nitre, boiled up, or Effervesced, to use a Chymical Word ; the Quantity of this Spirit was in Proportion to that of the Earth ; there likewise proceeded from it a dark Stinking Oil.

Thus we also find, that rotten Plants and Herbs (among which this Dung must be reckon'd, since it pro-

ceeded from Grass, which is the Food of Cows and Horses) yields a *Sal Volatile*, and the like kind of Oil, as is well known to those that deal in Chymistry.

Now how this Property of the Earth can contribute to the Production of all Plants, and to the farther Fertility of the Earth, I shall not enquire here; since these Discoveries are more proper to carry us on to others, than to the concluding any thing that affords the requisite Certainty.

SECT. XV. *The Earth produces Instruments fit to be apply'd in rendering itself more useful.*

AND that a Sceptical Mind may by more powerfully convinced of the Wisdom and Goodness of him that formed the Earth; Let him consider with himself, how a Man that must live by the Earth, is born unfit and unable to Cultivate the same without any Instruments. Can he then see no Design of his Creator therein? That this same Earth is not only disposed to produce Wood, but likewise Iron, of which Plows and other Tools proper for Tillage are composed. Now it was impossible without Fire to extract this Metal from the Matter with which it is mixed in the Mines, as it is well known to the Mineralists: So that tho' a Man were sufficiently provided with Earth, Wood and unwrought Iron, yet he would still want that which was necessary to render those things useful to him. But now again, continual Experience has taught all Men, that the same Earth does likewise furnish the necessary Materials of Fire, for making those things that are wanted; and that Wood, Coals, Turf, and the like, are of its Production; by which not only Iron is separated and purified from the foreign Mat-

Matters, that cleave to it, and is converted into the Instruments for Plowing and other Uses; but moreover that the raw Fruits, which are likewise produced by the Earth, are ripen'd and digested by the Fire, and so render'd fit for Food.

SECT. XVI. *Of Alchymists, and an Explanation of the Texts in Exod. xxxii. 20. and Deut. ix 21. about Gold.*

Now since we have here made mention of Iron, so far as it relates to cultivating the Earth; there would have been a large Field to treat more minutely concerning the same, and other Metals and Minerals, such as Lead, Tin, Copper, Silver, Gold and Precious Stones, which are all the Fruits and Productions of the Earth: But I shall only make these two Remarks *en passant* about Gold. *First*, How many Alchymists (to be pitied for their Folly, if not despised for their mistaken Avarice) were found in the last Century, who left nothing unattempted to make Gold from other and cheaper Matter. Innumerable Things were tried by innumerable Methods to compass this End; not only by great and eminent Persons, but by those of a middling and smaller Understanding; but all in vain hitherto: And the only Fruit that is to be reaped thereby, has been, that from hence a strong Proof may be fetched to convince these conceited Philosophers, who imagine they understand every thing, of the defect of their Judgments; and that something has place in Nature, concerning the Production of things which far surpasses their Wisdom. *Secondly*, Which I find my self obliged to insert here, is an answer to the Objections which many Unbelievers have brought against the Authority of the Books of *Moses*. We read in *Exodus xxxii. 20. that Moses took the Calf which they*

(the Israelites) *had made, and burnt it in the Fire, and Ground it to Powder.* The same Story is expressed in *Deut. xi. 21.* in these Words; *I took your Sin, the Calf which you had made, and burnt it with Fire, and stamped it, and ground it very small, even until it was as small as Dust.* And here our Adversaries think they have discover'd a great Argument against the Divinity of this Holy Word; forasmuch as all the Experiments that have been made upon Gold, even by keeping it whole Months in our strong Fires, have always hitherto taught us, that it can only be Melted, and not Burnt in such manner as to be beaten to Dust: Wherefore, according to them, this burning and afterwards grinding to Dust, seems to be entirely contrary to the Nature of Gold: Now not to return for answer, what has been already said by many very learned Expositors, in order to remove this Difficulty, and whom they, who are curious, may consult; I shall only add,

First, That altho' Gold in itself, and alone, is uncombustible, and seems incapable of being reduced by our Fire to such a Condition as to be stamp'd to Dust; yet it may be done by the Addition of some other Matter, as Chymists know very well, and so do they particularly that make colour'd Glass and Counterfeit Jewels, which, by mixing Gold with them, acquire the colour of Rubies, and which, together with the said mixed Gold, can be beaten to Powder. Now it is not said in that Text, that *Moses* used no additional Matter to bring the Gold to such a State; so that for this reason their Argument will not pass.

Secondly, This Argument is not conclusive, *no body knows how Gold can be burnt, therefore Gold cannot be burnt;* For if this be good Logick, they must proceed and say farther; *no body knows how Gold can be produced, therefore Gold cannot be produced;* which Experience teaches us to be false.

But

But *Thirdly*, to convince these miserable Seekers of Objections beyond a Reply, that it is by no means inconsistent with the Nature of Gold, to be thus burnt by Fire, as also that it can be beaten to Dust without any Mixture or Addition, we need only refer them to the Experiments performed by the great Burning-Glasses, some few Years ago.

SECT. XVII. *Gold may be burnt and reduced to Dust.*

THUS in the *History of the Royal French Academy*, 1699. p. 113. we find this Observation mention'd among those of Mr. *Tschirnhaus*, the Inventor of the said Burning-Glasses; That all Metals being placed the Focus of the Burning-Glass, will run into Glass; and that Gold in its Vitrification, assumed a fine Purple Colour.

But very nice and accurate are the Observations which Mr. *Hombérgh* made upon Gold in the pure Fire of the Sun, in the Year 1702. p. 186. and 1707. p. 50. as it is largely related in the Memoirs of the said Academy; where, after having acknowledged that Gold is not diminished in our common Fires, it is shewn, that by such a Collection of the Rays of the Sun in a Focus, or very near it, Gold is evaporated and turned partly into Fumes and partly into Glass; which, as the Author himself expresses it, p. 189, 190. is a real Conversion of this heavy Metal into a lighter Glass. At the end of the Memoir we find these Expressions; and thus we see by these Observations, that the Idea we had formed to our selves in Chymistry, of the Fixity or Fastness of Gold, cannot obtain any longer.

Now I ask those who have hitherto made this Text of Scripture a Foundation of their Infidelity, whether they must not confess, that their Argu

ments are quite defeated, after the making of this Experiment ; and that Gold is really burnt when it is partly evaporated, and partly changed into Glass : At least, it is a Chymical Truth, that Evaporation and Vitrification is the only thing that can be understood by *Burning*, if we take that word in its utmost Force. Besides that, hereby Gold, which does not otherwise easily appear capable of being made small by any Beating or Grinding (tho' in the last Age a famous Chymist has shewn us, that it may be done by a Mill made on purpose) is brought into such a Condition, that after its Vitrification it may be Ground to Dust. So that we here see all the Circumstances required by the Text, come to pass in the Business of Gold.

I do not say that that Man of GOD, *Moses*, did in this Case make use of such a Burning Glass, since the first mention of those Instruments is made by *Aristophanes* (see the *History of the Royal Academy of Sciences*, 1708.) but they were very imperfect, and like round Balls. It would have been sufficient, if he had the Knowledge of any such Fires as were so Pure and Strong as these Rays of the Sun thus collected. But that which is properly before us here is, that from this Experiment it is plainly and undeniably shewn, that what has been said about the Burning of Gold is possible : And as has been shewn above, *Moses* might have made use of the same or other kind of Mixtures, which the said Text does not exclude.

SECT.

SECT. XVIII. *About Precious Stones.*

FROM Metals it seems as if we ought to pass to the Consideration of Precious Stones, which if they be not beholden to the Earth for their Origin, at least almost all of 'em are found in and about the same. Those who acknowledge the Greatness of an All-creating GOD, may in this last Instance remark how Gracious and Bountiful he has been to Mankind, by taking care even for Ornaments likewise, and by producing out of the Earth Creatures of so noble a Lustre for that Purpose; by rendering them so far wonderful, that some, and the Chief of 'em, do excell in Firmness, and Incorruptibility, every thing that is yet known, whilst in the mean time their particular Structure has remained a Secret to us for so many Ages.

One of the Properties of Diamonds, till then unknown, has been discover'd by Mr. Boyle, and since taken notice of in the *French Academy*, 1707. p. 1. namely, that a polish'd Diamond being rubb'd against a Glass, will, in a dark Place, produce a Light as clear as that of a Burning Coal when strongly blown.

SECT. XIX. *Concerning the Loadstone.*

HE who had never seen a Loadstone before, would according to the *Philosophy of Ignorance* (for thus we ought to stile the Philosophy of those Men, who, because they cannot discover the Use of any thing, do therefore presently conclude, that it is useless) I say, according to such Principles, he would think that this Stone is one of the most useless things that GOD has created; to say nothing of the Dis-

agreeableness where with it present itself to our Sight.

But in case he were afterwards informed, that the same had not only the Property of attracting Iron itself, and of rendering it capable to draw other Iron to it; and this it does in such a manner, as even in the present Age, after so many Observations, with which whole Books are filled, is confessed to be still unknown by all true and unbiassed Philosophers: Could he then forbear to look upon this despicable Stone, as wonderful?

But in case one should disclose to him afterwards those Properties thereof, by which it shews the Northern Parts of the World, and by that Means chalks out a Path in the midst of the Sea for Ships, insomuch, that without it none durst venture to launch out into the great Ocean, and all Communication between those Parts of the World, that are so remote from one another, would be entirely interrupted: Would he not then when he saw the Merchandize and Product of other Countries, which are only attainable by the help of this Stone, pronounce it to be one of the most useful things in the World, and own himself, with the utmost Gratitude, obliged to receive it as a most valuable Present from a generous Benefactor?

SECT. XX. *When the Virtue of the Loadstone was discover'd.*

BUT lastly, when he adds to all this, that the Power of attracting Iron was long ago known to the Ancients, whereas that of finding out the North, and of serving for a Compass to Mariners was concealed from them; and that upon this occasion not only Christians in general, but among them, likewise great Mathematicians have observ'd

that

that which is noted by *Deschales*, in the Preface of his *Mathematical World*, namely, that about 300 Years ago, it pleased the great GOD to reveal this use of the Loadstone, when he had decreed according to his Divine Providence, with respect to Mankind, to reveal his Service and his Son to those Nations that were separated from us by the whole space of the Ocean. Will he judge that the Sentiments of those Persons are so groundless, who acknowledge in this Stone and the Use thereof, the Wisdom of GOD, and his wonderful Direction and Rule over all things, at the time of the Discovery of the Properties thereof?

SECT. XXI. *The Roundness of the Earth.*

IF we now pass on from the Matter of the Earth to the Structure of the Globe itself as, tho' it consist of inhabitable Land and Water, could any Body that contemplates with his Eyes the appearing Plane and Flatness thereof, have ever admitted it into his Thoughts, that the same is Round? And not much rather, by what he might conclude from the Motion of heavy Bodies downwards, affirm, with many of the most Learned of the Ancients, that it is impossible to ascribe a Globular Figure thereto? Forasmuch as those things that are under us, if they exerted their Gravity after the same manner, and according to the same way, would seem to have no Support, but must fall into the Air, which is below them. Whereas nevertheless, Modern Experience teaches us, that no more useful Figure could have been invented by the greatest Wisdom, than that of a Spherical or exactly Round, in order to make of so small a Place, so great and noble a Theatre of numberless Wonders. And can any one then satisfy himself with the bare Assertion, that this
Globe

Globe of the Earth has acquired such a Figure by Chance, or at least without any Understanding?

What various Opinions have there been broached of its Shape in former Ages? With respect to Astronomical Observations, by the Roundness of its Shadow upon the Eclipsing Moon, and by the Remarks, that upon the Sea, the Masts of the Ship are seen before the Ships themselves; this render'd the Globular Figure of the Earth very probable till the same was afterwards farther proved and confirmed experimentally, by several Voyages round the whole Earth.

If People in those dark Times had not so much relied upon their Understanding and Argumentations, as many do at present, and if they would have given Credit to what the great Creator of the Earth has said himself concerning it, they would have long since been satisfied of the true Form of the Earth: *See Isaiah xl. 22. It is he that sitteth upon the Circle of the Earth.* Can any thing more plainly express the Globular Figure of the Earth?

SECT. XXII. *The Earth is a flattish Bowl.*

SINCE we are now speaking of the Figure of the Earth; I cannot well pass by that Text of *Jeremiah vi. 22. Thus saith the Lord, behold, a People cometh from the North Country, and a great Nation shall be raised out of the side of the Earth:* Which words do likewise occur in the said Prophet, *Ch. xxxi. 8.* and *Ch. l. 41.* according to which the North is stiled the *Sides of the Earth.*

Now by the Sides of any thing, for Instance of of a Plank, of a Beam, of a Ship, of a Man or Beast, &c. we are wont to understand those Parts of the Circumference thereof, between which the Bodies themselves are Smallest or Thinnest, or

other-

otherwise between which the shortest Diameter thereof lyes.

Wherefore, if we suppose that the Earth is not perfectly globular, but that the middle Line of the is longer Equator, than that which may be drawn from the North Pole to the South, and in such manner, that all the middle Lines from the Pole to the Equator do continually increase in Length; the Earth, in respect to the Diameter thereof, will be smallest at both its Poles, and consequently the North and South Parts may be deemed both the *Sides of the Earth*.

Now 'tis well enough known to those that have look'd into the latest Enquiries of the accurate Moderns, that tho' they are wont to term the Earth a Spherical Body, without having any regard to the Inequalities that may be occasion'd therein by Mountains and Vales, yet it is not perfectly globular, but has a greater Protuberancy under the Equator, and grows continually lower or flatter towards the Poles.

Upon the Observation, that the Pendulum of a Clock at *Caienne*, near the Equator, must be $1\frac{1}{4}$ of a Line, or of $\frac{1}{16}$ of an Inch shorter, to strike exactly a Second, than it was necessary to be at *Paris*. Mr. *Huygens*, in his *Treatise of Gravity*, asserts, that the Earth is flatter at the Poles.

In Sir *Isaac Newton's Princip. Philos. Prop. XIX. Lib.3.* we see the same; as likewise in Dr. *Gregory's Astronom. p. 36, and 268.* and in Mr. *Whiston's Prælect. Phys. Mathem. Prop. XCIII. Corol. 2.* we find these Words, besides what is said in other Places thereof; *Since it is known by Observations and Experiences, that our Globe is really higher at the Equator than at the Poles.* In the History of the French Academy, 1700. p. 144. and in the Memoirs, p. 227. we find Observations taken at *Lisbon* and *Paraiba* in *America*, which seem expressly to confirm the Shortening of the

Pendulum in the Approach to the Equator, and consequently to the greater Flatness of the Earth at the Poles, tho' the exact Greatness is scarce to be determined by these Observations.

But that we may not be liable to the Difficulties and Objections that shall be made against the Hypotheses used by some for the Proof thereof, it is very remarkable, what is said upon the same Subject, in the History of the said Academy for the Year 1701. p. 120. and in the Memoirs, p. 237, &c. where Mr. *Cassini*, carrying on the Meridian of France to the Pyrenean Mountains, by order of the King, has nicely measured the length of each Degree of the same, and found in $7\frac{1}{2}$ Degrees between the Parallels of *Amiens* and *Coljure*, which he has compared with each other, that the Greatness of each continually increased as they drew nearer to the Equinoctial, and consequently decreas'd as they approached to the Poles. So that, without contesting too strictly the exact and Geometrical Figure of the Earth, and without admitting any Hypothesis for a Foundation, in case what Mr. *Cassini* has really found in each of these Degrees obtains in all of 'em from the Equator to the Poles, certainly the Equator or Equinoctial itself is greater than any Meridian or Circle passing thro' both the Poles: And the Earth is really a Globe but a little flattish at the Poles. The same may be observed by the help of Telescopes in the Planet of *Jupiter* itself, and was so done by Messieurs *Cassini* and *Flamsteed*; see *Whiston's Prop.* 93. and others.

Now, whether this be the Experiments of which Mr. *Whiston* makes mention in the place above-quoted, I know not, because I do not find them added to it. This is certain, that this Author, in his *Prælect. Astron.* II. *Prop.* II. p. 8. of the Earth, says, that it is *about or almost Spherical*; yet with so little Difference, that he reckons them among those

those Trifles that are not worthy to be taken notice of in Astronomy, because the Difference which the small Flatness thereof may occasion is in a manner insensible.

SECT. XXII. *The Gravity of all Earthly Bodies.*

I HAVE oftentimes consider'd with great Astonishment, that wonderful Motion which the Philosophers call *Gravity* or *Heaviness*, and by which every thing that we know upon the Earth is attracted or driven down and towards this Globe.

I shall not here relate nor dispute the various Arguments of Philosophers about the same; whether it is to be consider'd as accidental only, and whether it be occasion'd by the Highness of other Bodies which force the heavier downwards. This is however true, that all Corporeal Things that are known to Mankind upon this Globe, have their Gravity or Weight; not excepting the Air and the Fire, nor even that fine and pure Fire itself which has first pass'd thro' the Glass: All which, according to the Discoveries of these Times, have been visibly proved by a nice Balance, to have their Weight. See *Boyle de penetrabilitate vitri à ponderabilibus partibus flammæ*. Yea, that the pure Light itself, being collected by a Burning Glass, may be united to other Bodies and render them more heavy, will be shewn hereafter in *Contemplation XXIV.* by the Experiment of Mr. *Humbergh*.

Now how strongly this Gravity operates, does even appear from the Pressure of Bodies, which do otherwise seem to be without Motion. From hence it is we see great Ships sink, and often times very strong Floors of Houses fall in by being overladen.

Now, I ask any reasonable Person, whether he can believe, that stupid and insensible Things, which

which cannot produce the least Motion in themselves, are capable of observing such exact Laws, without the Direction not only of a Powerful, but likewise of a Wise Being? For in case C be the Centre of the Earth (*Tab. XV. Fig. 3.*) and the Circle drawn from thence be a great Circle upon its Superficies, and the Lines F G, H I, K L, M N, that touch the said Circle, represent the Horizons of each Place; every one knows, that if a Stone, or other heavy Body, were let fall at A, it would move according to the Line A C; if at B, according to B C; at D, according to D C; and at E, according to E C; and that this is a true Position, is well known to those Pilots that have sailed partly or wholly round the Earth, who must all bear Witness, that such is the Method of their Fathoming in the different Places in which they found themselves.

Now let the Cause of this Gravity be such, as every one, according to his own Philosophical System, shall think fit; yet he must nevertheless acknowledge, that without this Property the Earth would be uninhabitable, especially, if he comprehends what has been said above concerning the Weight of the Air and Water.

SECT. XXIII, and XXIV. *The Centre of the Earth is a Nothing.*

Now not to ask, whether any one can imagine, that it comes to pass without a wise Direction, that a Body wholly ignorant and insensible, being placed at A, shall move from A to C; and being at E, from E to C, along a streight Line directly opposite to it; and that in all Places where any Body falls down upon the Earth, it shall always chuse the nearest and shortest Way to the Centre thereof? Those who seriously contemplate

plate this great Wonder, that all Bodies, how large and unwieldy soever they be, without the least knowledge of what they themselves are doing, will move with so dreadful a Force to a Mathematical Point, to a mere *Ens Rationis*, which has no Existence out of the Thoughts of him that conceives it; and tho' it may be justly called in Bodies a perfect Nothing, will yet remain hanging to it. Can they, without acknowledging the Wisdom of God in his Holy Word, read the Expression made use of by *Job*, ch. xxvi. v. 7. *he hangeth the Earth upon Nothing?*

As great a Paradox as this may appear to be, the obdurate Atheist, if he understands any thing of the Mathematicks, must own, that it is an undeniable Truth, as the Holy Penman has there expressed it. Is not every thing heavy among all Earthly Bodies that have yet fallen under Humane Enquiries? Does not this Heaviness cause every thing to descend towards the Centre of the Earth? Does not the whole Body of the Earth dispose itself into a Circular Figure about the said Centre? And there fore in the very Words of *Job*, does not the Earth by such Gravity hang upon nothing on all Sides? Is not then the Centre a perfect *Nothing* in itself, and exists only in the Idea of Men? Why do we hear *Euclides Defin. I. Lib. I.* describe the same thus; *A Point is that which has no Parts?* And to shew that the following Mathematicians held it to be no Part of Matter, see what *Clavius* says of it in his Annotations, namely, that *no Example can be given of it in material things.* Thus we see, that *Whiston*, in his Treatise above-mention'd, *Prop. lxxxviii. Corol. 2.* says, that the common Centre of Gravity of things in this World, being only a Mathematical Point, is plainly a *Nothing*. The like Testimonies one might produce from more Mathematicians. Now if be not material what is it then

then other than a *Nothing* in material Things, and a mere Notion only, that we form to ourselves of the Bounds or Limits of something? The Reasons produced by true Mathematicians, to shew that a Point is without Parts and Magnitude, may be found by those that are unexperienced in these Studies, and who are therefore shock'd at this Assertion, elsewhere, this not being the proper place for it, it being sufficient for our purpose to have prov'd the Truth of *Job's* Words, and so far to have consider'd the Nature of *Gravity*, as to shew, that it is impossible for any one to ascribe it to Chance or to Ignorant Laws of Nature, but rather to the Will and Power of GOD only, especially, since no Man hitherto has been able to assign any other Satisfactory Cause; insomuch, that after all the Disputes and Caviling about it, the greatest Modern Mathematicians and Enquirers into Nature have been forced to come to this Conclusion, that Gravity is a general Law, and as old as the World itself; and that GOD was pleased to stamp it upon Matter in the Beginning; and, that therefore we ought no more to ask how it comes to pass, that all Bodies gravitate, that how it happens, how they are moved. It is well known, that this is the Language of some of the greatest Mathematicians of this Age.

SECT. XXV. *The Globe of the Earth keeps the same Obliquity.*

HAVING made some mention of the Gravity, I cannot forbear observing with great Reverence, that surprising Wonder which all Natural Philosophers (whatever some of 'em may pretend to Conjecture) have acknowledged to be one of the Secrets of the great Creator; and even to this Day are forced to consider it as such. Now, whether

ther we suppose that the Globe of the Earth, *p e mf* (*Tab. XV. Fig. 4.*) stands still, and that the Starry Firmament *P E M F*, together with the Sun *O*, and the rest of the Constellations, daily move about it : Or, whether, with others, we suppose, for greater Conveniency in some Occasions, that in *Tab. XV. Fig. 5.* the said Globe of the Earth in carried round the Sun *O*, thro' *A, B, C, D*, and is daily moved about its own Axis *p m* : This is certain, that the said Axis *p m*, does always respect the same Place *P* and *M* of the Heavens, in the fourth Figure, or remains always Equi-distant to itself in the fifth Figure ; and that so the Earth, and without any support, does thereby always preserve its own Opportunity and Obliquity, at least so much, that the Astronomers have never been able to observe it otherwise ; and, such as have imagined that they have found it otherwise, have never been able to prove such a Discovery. And, which is still more wonderful, notwithstanding the Globular Figure of the said Earth, and notwithstanding the Opinion that many have entertained, that the Earth's remaining in its present State and Obliquity, is owing to the Equilibrium of its Parts, the same has so frequently undergone such great Revolutions, that it should seem almost impossible to those that judge rightly of things, that it has not thereby been confounded and dissolved, or at least put into different Motions.

SECT. XXVI. *Without the Obliquity of the Earth, there would be reason to apprehend a General Destruction.*

FOR a Proof hereof, let any one consider those dreadful Burning Mountains, which are found in so many Parts of the World, and at such Distances from each other; by which the Earth has been destroyed in so many Places: Especially if those Fire-pits (as one may perhaps conclude from the Relations of them given us by Mr. *Baglivi*, p. 510, &c.) according to the Sentiments of many of the Learned, do entertain a Communication with each other, by great Rivers of Fire extending themselves from one Part of the Earth to the other, and even under the Bottom of the Sea too: For which reason the Earth seems necessarily to become lighter in those Parts where so much of it has been burnt, and vomited out in Smoak and Ashes.

Add to this those terrible Inundations, among which, according to all Traditions, the whole *Zuider-Sea* is one, and the violent Streams of such great Parts of the Ocean, which by Winds, by Ebbings, and Flowings, and other Causes, do transplant such an unconceivable Weight of Waters from one Part of the Globe to another; by all which the Gravity thereof must needs be changed into several Places. Not to mention those Earthquakes that are felt over all the World, by which this Globe being moved, may make us all justly apprehend a Change in the State and Condition thereof.

Now in Case that by all these Causes acting with such terrible Force, it should once happen, that the Earth should totter, and depart from its Place in any manner, what could there else be expected but general Ruin and Destruction, where every

every thing whatever changed, its Air and Climate. For let it be supposed, that those who in *Tab. XV. Fig. 4, 5.* dwelt under the Line *ef*, or in the Torrid Zone, near to it, should be carried by such a shock of the Earth to some of the Countries under the Poles *p* or *m*, or one of the Frigid Zones; by which Means those Nations which now dwell under either of the Poles, would be carried into the stifling Air, under or near the Equinox. Can it then be doubted, that all that was accustomed to the violent Heat of the one, even Men, Beasts and Plants, would for the most Part perish and be destroyed, by being transplanted to the excessive cold Regions, and so on the contrary. Now all these Evils which would certainly follow, are hereby obviated, and altho' the Globe of the Earth might undergo so many Revolutions in its Parts, tho' it should become heavier in one place and lighter in another, whereby the Balance of its Structure might be alter'd, yet it would however steadfastly and immoveably preserve the same Obliquity.

SECT. XXVII. *Convictions from thence.*

Now that among so many Causes, which seem adapted to produce the contrary Effect, the Globe has unchangeably kept this its State and Condition, can result from nothing else than the miraculous Operation of a mighty Providence. For if any one should ascribe it to a Law of Nature, to its own Gravity, or, as some think, to a magnetical Virtue; let him tell us how it comes to pass that such a Law of Nature is always unvariable in its Effects, when at the same time the Earth upon which these Laws operate, changes its Composition, with respect to Levity and Gravity, to Cavity and Solidity.

SECT. XXVIII. *The Earth remains above the Water notwithstanding its greater Gravity.*

NOW in order to lay before an Atheist something that he shall not be able to fathom or conceive ; Let me ask him the reason why, since Earth is heavier than Water, the Waters do not stand above the Earth, surrounding the same in the like manner as the Air, since it seems to be past doubt, that one should follow, as well as t'other, from the Laws of Gravity?

Tis in vain for any one to alledge, especially such a one who will not acknowledge herein a Wonder-working-God, that the Sea and Waters being shut up in the Cavities of the Earth, it would be impossible that such a thing could happen. For supposing (as the Experience of Inland Waters, for Instance, those of the *Harlemer Meer*, or *Lake of Harlem*, has taught many People to their Damage) that the continual Beating of the Waves would in time wear away every thing; it seems to be a necessary Consequence, that the Banks and Shores being thereby washed away, this Matter would first mingle itself with the Water, and afterwards sink to the Bottom by its greater Weight, and so render the Seas and other Waters more and more Shallow; by which Means the dry Land continually decreasing, the whole Earth would at last be encompass'd and cover'd with Water, tho' not so deep as the present Cavities of the Sea. Yet we see the contrary happen, and the dry Land remaining inhabitable, notwithstanding the rage of Seas and Rivers.

SECT. XXIX. *Concerning the Torrid-Zone.*

To pass on to something else : It is well known, that all the Geographers do divide the Superficies of this Globe into five Zones. The first they call the *Torrid Zone* ; this is that part of the Superficies which extends itself from the *Equator e f* (*Tab. XVI. Fig. 1.*) on each Side, to the Tropicks *c d*.

Now that the old Geographers held it for an unquestionable Truth, that this Zone was barren and uninhabitable by the intollerable Heat, appears strongly enough from their Writings ; nor were they so much to blame, if we reflect upon the influence of the Sun in other Parts of the World : Since this great and burning Luminary moveing twice a Year in the Circle *A Y D*, called the *Ecliptic*, or the Sun's Way, passes directly over those Lands that lye between the two Tropicks *ab x c d*.

And this very rational Notion, as to outward appearance, has so long obtained every where, till Experience teaching the contrary, has therein manifested the Divinity and unconceivable Wisdom of the great Creator, who has graciously prevented by other Means this all consuming Heat, which with respect to the Scituation of those Countries, and the Course of the Sun, seem to be a necessary Consequence, from destroying the same.

SECT. XXX. *The Torrid Zone inhabitable, by means of Mountains.*

To be assur'd of this Wonder, we need only take the afore-mention'd Island of *St. Thomas* for an Example ; this Island lies under the Line, as here at *X*, in the middle of the *Torrid Zone* ; of which

nevertheless, all that write about it do unanimously witness the Wholesomeness of the Air for the Inhabitants and the Fruitfulness of the Country. To which purpose we need only consult the little *Atlas* of *Mercator*, or any other Books that have treated of the same.

Now I beseech every one that can yet doubt, whether the World be made with Wisdom, to reflect with himself, whether it may be deduced from the ignorant Laws of Nature, or from mere Chance, that, to the end the Sun should not render this Island uninhabitable, there is a great Mountain placed in the middle, and overgrown with numbers of Woods; the Tops of which, notwithstanding that the Heat may seem to dry them quite up, are always cover'd with so many Clouds, that the descending Waters, which proceed from thence, are not only sufficient to produce other Fruits, but even Sugar-Canes themselves. Inasmuch, that in the very hottest Days this Mountain appears cover'd with a continual Cloud; the Reason of which is, that a much greater Quantity of Vapours are then attracted by the Sun from the Sea; and the Air being likewise much more rarified by the Heat, carries the Vapours of Water that are mixed with it, more to the Cold and Shadowy Places of this Mountain, thereby pressing them more closely together, and so encrease the Weight of the Clouds. Now how the Mountains concur in producing these Effects, has already been in some measure shewn before.

Now if any one should refuse to acknowledge a gracious Providence of GOD in this whole Matter, and will pretend, that this is only peculiar to single Place, and consequently, that it may be the effect of Chance, he may learn from the Description of *Madagascar*, in the Geography of Mr. *Robbe*, and others, that there are likewise Woods and Mountains in the
middle

middle of that Island, from whence Rivers flow on all sides, which render that Country (tho' lying in the hottest Part of the World) in respect to the Sun, equal in Fertility to the best Climates of the Earth : And this you will find observed in several other Places.

SECT. XXXI. *The Inundation of Rivers do likewise render the Torrid Zone Habitable.*

BUT in case any other of these miserable Philosophers should again, according to their manner, start new Difficulties, and fancy, that since what has been advanced above, has happen'd in several Places, it might be the necessary Consequences of Natural Laws, they may likewise be convinced of the unreasonableness of such Opinions, from other and different Means, which, besides the foregoing, the Wisdom of GOD has been pleased to make use of in rendering those Countries Fruitful, which would be otherwise quite scorch'd up by the Rays of the Sun.

Now, not to speak of *Egypt* again, one part of which lies under the Tropick *ab*, and where it is thought to be the very hottest, because the Sun does not only pass twice a Year directly over their Heads, as it happens in all Parts of the Torrid Zone ; but also, because it remains a much longer time over the Countries lying about the Tropick, than it does at the Equator, which it passes by more swiftly ; and yet this *Egypt* is made one of the most Plentiful and Fruitful Countries of the World by the overflowing of the River *Nile*. I say, besides *Egypt*, the dry and barren Country of the *Blacks*, commonly called *Nigritia* or *Nigritarum Regio*, may serve for a Proof. Which likewise stretches itself from the 8th to the 23d Degree of Latitude, and consequently very near to

the Tropick of *Cancer*, in the hottest Part of the Torrid Zone, and is overflowed in the like manner by the River *Niger*; which leaving a kind of Mudd every Year upon this scorched Country, makes it become the most fertile of all *Africa*. See concerning the same, Mr. *Robbe's* Geography, as also that of *Varenius*, lib. I. Cap. 16. §. 20. about several Rivers besides the above-mention'd, that produce the same Advantages. Many of which there named, and amongst them particularly the River *Zaire*, do overflow their Banks yearly, so that this last renders the Kingdom of *Congo*, where the Air in clear Weather is intollerably Hot, exceeding Fruitful in all Sorts of Herbs and Plants that are good for Food. He therefore that is surpris'd hereat, and has a mind to be farther informed, how in such a Burning Climate, the Earth yields so great a Plenty of all things, may learn from the abovemention'd Geography of Mr. *Robbe*, and the so often praised *Varenius*, how the Rivers *Indus* and *Ganges* overflowing always in *June*, *July* and *August*, do Water whole Kingdoms lying about 'em, and make them Fruitful to a great Degree; as they likewise serve for a sufficient Provision of Water to the Inhabitants during the rest of the Months, in which there hardly falls any Rain.

After how wonderful a manner the Heat of this Torrid Zone is farther qualified in several Places by cool Breezes and Rains, is likewise shewn by *Varenius*, Lib. II. Cap. 26. §. 11. even so far, that by other means, which the Wisdom of the Almighty has been there pleased to use, the Seasons seem frequently to run contrary to the approaching and receding of the Sun. It would be too tedious, and according to all probability an unnecessary Work too, to enquire into all the Causes thereof.

SECT. XXXII. *Convictions from hence.*

Now let me once again ask these Philosophers, that are really worthy of Compassion, and who will have all things come to pass as they are, without the Wisdom of the Creator and Preserver of all things, whether, if any Body had found a Method to furnish a little District of Land with a milder Air, and with as much Water as is wanted, and which without the same must have perished by Drought and Barrenness, together, with all the Men, Beasts and Plants that were upon it; it could be denied, that the Wisdom of Him that found out and effected the same (especially if the Knowledge and Power of the greatest Number and most Skilful of Men, would have sufficed for that Purpose) were not worthy of the highest Praise; and, whether they, or any one else, could imagine, that the Canals and Aqueducts whereby in the drained Meers or Lakes of *North-Holland*, the Lands are water'd in dry Seasons, and the Cattle are provided with Drink, could have been brought about without the Contrivance of a Skillful Engineer?

Now this is what we see performed, not in drained Meers or Fens, but in vast Kingdoms; not a few Cattle water'd, but Millions of Men, Millions of Wild and Tame Beasts, Millions of Trees, Shrubs, Plants, Corn, and other Herbs, preserved alive thereby; not some few Acres of Land, but Whole and Great, and otherwise Useless Parts of the World, fertilized thereby, and put into a Condition, from the abundance of their Productions, to communicate their Agreeableness to other People. Here are no Sluices or Mills made use of, which must be yearly supported at the Charge of the Country, but prodigious Bodies

dies, and vast Mountains discharging those Functions ; and which having been once placed there by the great Director of all things, remain there still without any Expence to those that reap the Benefit of them, being fitted to perform this their great Work thousands of Years, without any Diminution or Attrition. Here are no Artificial Canals or Sluices of a small Extent necessary for this Purpose, but vast Floods of Water and the greatest Rivers of the World.

Now, since all this is incomparably more Noble and of greater Benefit than that which every one readily confesses to be brought to pass in the aforesaid *Meers*, by humane Contrivance and Wisdom ; What Reason can these miserable Philosophers produce, to justify their persevering in their Opinions, that the same is here done without any Wisdom ?

SECT. XXXIII. *Concerning the Temperate Zones.*

AFTER this Torrid Zone *abcd*, (*Tab. XVI. Fig. 1.*) there follows two others, one on the one side *abhg*, and t'other on the other *cdki* ; which, in respect of the lesser Heat, as in the Torrid Zone *abcd*, and lesser Cold, as in the two Frigid Zones *gph*, and *imk* ; and therefore on account of the greater Temperament of the Air, are called the Temperate Zones.

Taking then *p* for the North Pole, *abhg* is the North Temperate Zone, and *cdki* the South ; the former of which is inhabited by us, and almost all *Europe*, and the greatest Part of *Asia*, and contains all those Lands and Seas which we may see in the Mapp of the World, lying between the Tropic of *Cancer ab*, and the Polar Circle *gh* ; the South Temperate Zone *cdki*, which may be likewise seen there, is mostly engross'd by Seas.

SECT.

SECT. XXXIV. *The Advantages of the most Northern Parts.*

IT is necessary to expatiate here more particularly upon the Northern Zone. Every thing about us, or that has been represented in all these *Contemplations*, centers in this, namely, to manifest the Power, Wisdom and Goodness of GOD, which has shined out so brightly in these Parts of the World. This is certain, that in Fruitfulness, in the Temperature of the Seasons, and particularly in the Learning and Understanding of its Inhabitants, it will give place to no other whatever; forasmuch as it is beyond all doubt, that in the Government of its Countries, in Commerce, in Navigations, in the Arts of War, and in an infinite Number of other Sciences, it far exceeds all other People.

But the greatest Benefit of all, and that which incomparably exalts this Zone above all the other Parts of the whole Globe, is, that the Knowledge of the True GOD, and his right Worship, have here their present Seat: Since that this same bright Sun is now set in respect to unhappy *Asia*, GOD having thought these People worthy (which exceeds all Humane Gratitude) to whom he might reveal Himself and his Holy Word, and by them to propagate and diffuse the Knowledge thereof to other Nations.

A truly upright Soul, such as loves and fears GOD, will esteem nothing more detestable, nothing more unreasonable, than to imagine, that the Worship of him also has acquired by Chance, or by a stupid Necessity of Natural Laws, its so just and equitable Principles, worthy of the True GOD, and surpassing all other Idolatrous Worships.

And

And if an Atheist would but ever have taken the Pains to examine the adorable Wisdom of GOD, in this his Word, and the fundamental Knowledge therein of all Creatures; if he would but compare the exact Accomplishment of so many Prophecies with History; if he would reflect upon the wonderful Preservation of the holy Scriptures, in spite of the Rage and Persecution of the great Tyrants and Opposers of the World, he will be able to produce very few Arguments to make an impartial Person believe, that it is the Effect of mere Chance that GOD is Worshiped in this Part of the World, after the manner contained in his Word.

SECT. XXXV. *The Christian Religion is no Art of Politicians*

THE Atheists and Infidels have never yet been so Foolish and Brutal (if we may use such hard Words) as to ascribe that impression which every one has of a Divinity or his Worship, (how much soever they are disposed to deduce every thing from thence) to mere Chance or Fatality. Wherefore, being now obliged to seek for other Subterfuges and Evasions, they now refer it to the Arts and Stratagems of great Politicians, who thereby endeavour to keep in awe the People under their Government.

That this has Place in some Pagan Religions, as also in the *Mahometan*, is easie to be shewn, they having been established by the Force of Arms. But nothing is more impossible than to prove the same in the Christian Religion. For if it be the Policy of Rulers and Princes to bridle and keep in awe a giddy Multitude, why has not such Policy, with the Addition likewise of all their Power (whereby they have extirpated hundreds of thousands

sands for the Confession of our Lord JESUS CHRIST) been able to suppress a little, contemptible, innocent, unlearned and defenceless People, nor get the better of those Principles so pernicious to their Atheistical Authority? By which Principles, Men were taught indeed to submit themselves to the Powers that were over them; because there is no Power but of GOD, and, because the Powers that be are ordained of Him, *Rom. xiii. 1.* But also, on the other side, (which is by no means to be endured by an Atheistical Governor, who would direct all things according to his own Pleasure) that Subjects are obliged in Case the Worship and Revealed Will of GOD were opposed even by the mightiest of Monarchs, to deny their Fear and Obedience. Was there ever any Religion better Calculated to oppose a Supream Power, that does not own GOD, like this, tho' in all other Cases it makes the most Obedient Subjects? And, can any Prince, who accounts his Religion nothing else but a Bridle for the People, any wise endure to hear even the meanest of his Subjects say, with the Apostles, in *Acts v. 29.* *We ought to obey God rather than Man?* Or, will he suffer a Religion to be exercised in any Place under his, where the Founder of it shall give this express Charge to those that exercise it, when persecuted for his Name-sake; *Be not afraid of them that kill the Body, and after that, have no more that they can do. But I will forewarn you whom you shall fear: fear him, which after he hath killed, hath Power to cast into Hell; Yea, I say unto you, fear him,* *Luke xii. 4, 5.* from whence an Atheist himself may judge, if all Religions owe their beginning to State-Craft only, whether the Christian would not long before this have been at an End: And since that could not be compassed by so many bloody Persecutions, and raging Cruelties of the highest Worldly Powers, whether the

said

said Religion must not have been preserved from the very Rise of it to this Day, against all the Attempts and Designs of those that would extirpate it, by the Intervention of a much Higher and more Resilient Power ?

SECT. XXXVI. *Atheists differ from the Wisest Men.*

NOW, to return from this Digression to the Business in Hand, it is undeniable, that this Northern Temperate Zone is inhabited by the wisest and most learned Men ; most of whom acknowledge a GOD and Supream Director of all Things ; from whence it is plain, that the owning a Deity, which has made and supported all things, is received and maintained by the wisest of all People. If now a deplorable Sceptick, and who still pretends to doubt of these great Truths, will not continue arrogantly to maintain, that the wisest Men are the greatest Impostors, and that the less Knowing are all cheated, and that he himself is the only Wise and Righteous Man ; he will at least, by comparing all these things together, find a just Cause silently to sit down ; and whatever his Philosophy might have taught him before, to enquire farther, whether his persevering in this Conceit, that he is the only Wise Man, be not the greatest of Follies ; and, whether the Proofs made use of by others, to shew, that there is a GOD, are not stronger than those to which he hitherto adhered : Lastly, Whether from the Works of Nature, the Wisdom of the Creator may not as justly be infer'd as the Skill of the best Workman from those of Art. Which trouble, if he please to take, he will have got a great Way already, unless he be entirely abandon'd to his own unhappy Principles.

SECT. XXXVII. *Concerning the Frigid Zones.*

THE two last Zones (*Tab. XVI. Fig. 1.*) are those that are called the *Frigid* or *Cold Zones*, of which the Southern *k m i*, lies under the Southern Pole *m*, and seem as yet to be entirely unknown to Geographers, being represented upon their Maps very doubtfully, either by Seas or by the *Terra Australis Incognita*.

The Northern Frigid Zone *g p h*, especially if one approach pretty near to the North Pole *p*, discovers nothing else but uninhabited Desarts, frightful Rocks and Mountains of Snow and Ice for the most Part, concerning which, the Descriptions of *Nova Zembla*, *Spitsberg* and *Greenland*, may be consulted.

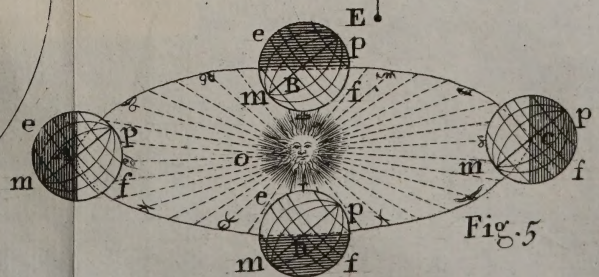
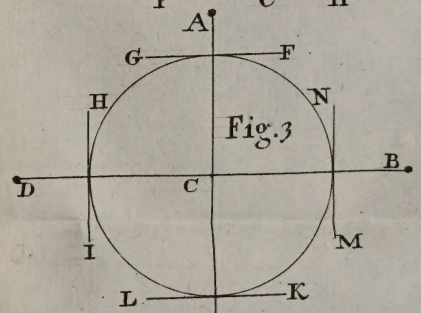
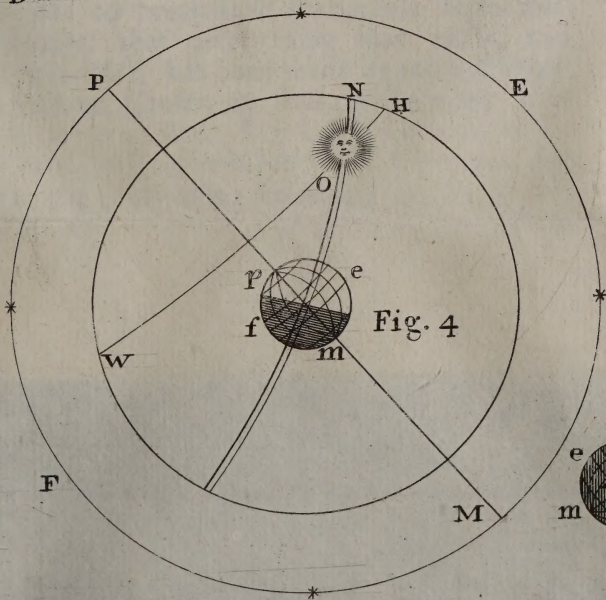
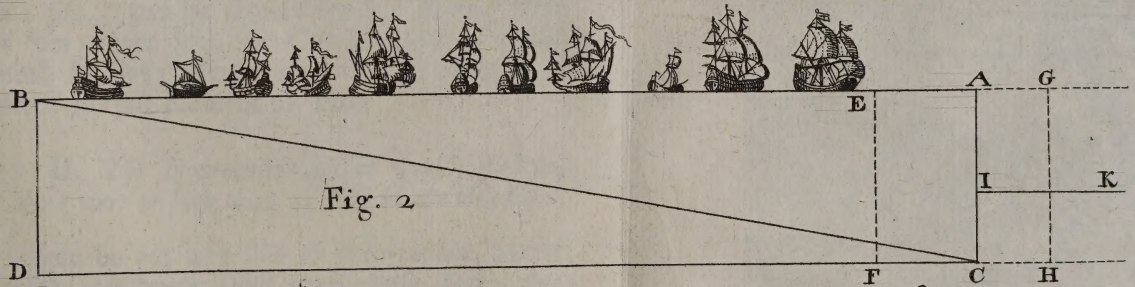
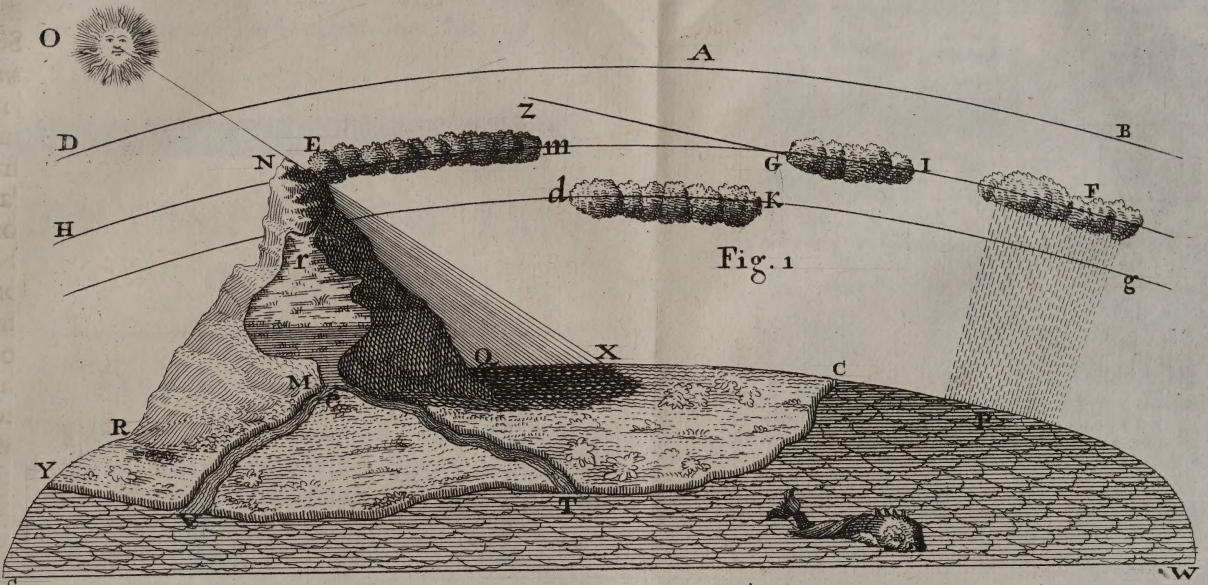
SECT. XXXVIII. *The Impossibility of approaching the Poles.*

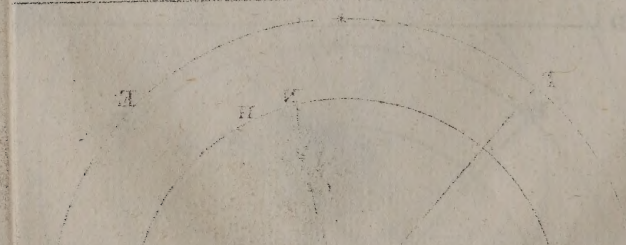
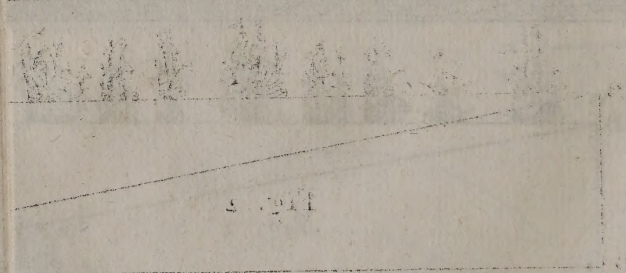
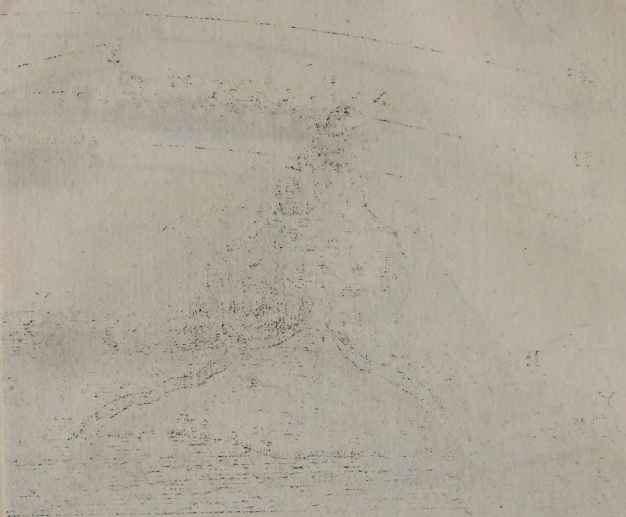
ONE can hardly read without Astonishment, what *Kircher* says in his *Subterraneous World*, and which he confirms by a Cloud of Witnesses, namely, as Men approach the North Pole *p*, the Sea is driven towards it with so irresistible a Force, and, as if it fell from a Cataract, that many, who have had the Misfortune to come within the said Stream, have been hurried away, Men, Vessels and all, and never seen again; and on the contrary, those who have endeavour'd to Sail towards the South Pole *m*, have found the Sea flowing against them with so terrible a Strength, that neither Sails nor Oars could bring them nearer to it.

I leave this Relation to its own Weight; but how little Hope there is ever to discover and to learn the exact Dimensions of the Poles may be learned from all the Voyagers that have bent their Course

Course that way. Certainly that in *Kepler's* time, which is something more than a Century, we were ignorant of every thing concerning them, and did not so much as know whether it was Land or Sea under the Poles, is sufficiently shewn by his *Epitome Astronom.* p. 166, and 150. *De Stair*, does likewise represent in his *Physiology* the invincible Difficulties of ever getting thither; saying, p. 487, that when the *Hollanders* endeavour'd to find a Passage to the *East-Indies* by the North, and therefore were obliged to Steer their Course towards that Pole, the Compass lost all its Virtue and Direction; by which means all Hopes of advancing farther seem'd to be entirely cut off. Yea, to be convinced, that it is still unknown to all Men, what are the Countries lying under the Poles, we need only cast our Eyes upon the *Cosmotheoros* of Mr. *Huygens*, p. 119. who, in plain Words affirms the same, adding thereto, that he may express the Difficulty, if not Impossibility thereof, in the following wish: *O if one might but once see those Regions.*

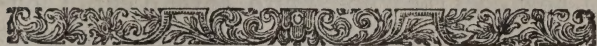
But altho' some might think it possible, that in following Ages the same may be discover'd, yet the absolute Impossibility of ever attaining to the last Degree of the Earth's breadth, is daily more plain by New Experiments; the vain Attempts of the boldst Sailors are every time so many new Proofs thereof. But that which seems to frustrate all Hopes, even for the future, are the impracticable and always obstructing Mountains of Ice, which are found there Yearly by our *Green-Land* Traders, and which, according to all probability, may Date their Age from that of the World; since the Sun seems never to have had so much Strength as to be capable of dissolving these vast Tracts of Ice, frozen by so many and such long Winters





is named from all the Voyagers that have been there
 Gorda

Winters. So that any access to the Poles will be always defeated thereby, and as long as the Earth continues in the same Position with respect to the Sun, the same Difficulties are like to remain.



CONTEMPLATION XXI.

Of FIRE.

SECT. I. *Transition to FIRE.*

NOW, tho' we do not, like some Philosophers, assert, the Earth, Air, Water and Fire to be the only Principles or Foundation of all Things, nor pretend to limit the Wisdom of the Almighty to such a Quantity, if we may so speak; yet it can be denied by no Body, that all of 'em center into the Composition of many Natural Bodies: Wherefore we shall proceed to consider this last Element of Fire.

SECT. II. *The Inconveniencies that would befall us, if there were no such thing as Fire in the World.*

IF there be any one still so unfortunate, as not to be able to break loose from those deplorable Sentiments, that every thing that exists, and even Fire itself, has been made by mere Chance and ignorant Causes, at least, without any wise and determinate End; Let such a one retire within himself, and contemplate this Globe of the Earth, and every thing belonging to it, in the

State in which he might suppose himself and that to be, in case there was no such thing as Fire.

After the setting of the Sun, and all other Heavenly Lights (to take no notice here that the Light thereof does even in a great measure consist of Fire, or brings a great deal of that Element along with it) how does the whole Earth, cover'd with Cloudy and Nocturnal Vapours, differ from the most dismal Subterraneous Caverns and Dungeons? Since during such a time no Man would be able to move one Foot forwards, or to dispatch any kind of Business. Without Fire, which by the Means of Candles, Lamps, Torches and the like, affords us Light in the greatest Darkness, what difference would there be between our Condition, and that of those Men who are blind half their Life-time? Without Fire, most of the Productions of the Earth, which serve Mankind for Food, for Refreshment, and for Dainties, would not be fit to be used in many Countries to those Purposes, nor could be chewed by the Teeth, nor digested by the Stomach. And every Body to whom the way of Living, and of preparing our Diet in these Countries is known, must be convinced, that neither Bread nor Flesh, nor most of the Fruits of the Ground, or of Trees, would be of much use without these Means, but would turn to an unwholsome, crude Nourishment and perhaps to no Nourishment at all.

Would not the dreadful Cold of Winter, if not moderated by Fire, be capable of Dispeopling whole Countries, and of Freezing to Death numbers of Women and Children, that are not capable of keeping themselves Warm by strong and violent Motions?

If there were no Metals for the use of Mankind, (to say nothing of Gold and Silver which may be the most easily spared) especially if there were no Iron which furnishes us with so many Instruments
for

for numberless Uses ; for Plowing, Building, and in a manner, for all other Arts and Purposes ; every one may easily conclude, under what Inconveniencies all Mankind would Labour : Now tho' the Iron and other Mines should be infinitely more in Number than they now are, yet it is sufficiently known, that without Fire, no use could be made of them, nor could they be Smelted or Separated from their respective Oars.

SECT. III. *Convictions from thence.*

To reckon no more, let an Atheist represent to himself the World, in such a Condition, that he and all Men should find themselves without Light in Darknes, without Warmth in Cold, without any Preparation for Raw Food, without all the Conveniencies which Metals, and chiefly Iron would afford them. Now, if any one should come and tell him, that he had discover'd such a Matter by which all these Defects and Wants might be supplied, and the World become happier in so many Instances, would not even the most obstinate Infidel acknowledge the Inventor to be a very wise Person ? Now since the same is performed by a Being infinitely Superior to that of a Man, and after a much more sublime and wonderful manner, why will he refuse to own the Wisdom of such a Being.

SECT. IV. *It is still uncertain what Fire is.*

THERE have never been wanting among the Enquirers into the Secrets of Nature, those that have endeavour'd to discover what Fire is in itself, and what are its Properties ; and we seem to have just Cause to think, whether Mr. *De Stair*, who has in a manner consider'd all Opinions, has not

fallen upon the best Notion thereof in the following Words; *Explor. VI. §. I.* There is nothing in Nature more obvious to the Senses, and nothing less intelligible than the Nature of Fire.

SECT. V. *The First Notion concerning Fire.*

TWO Opinions which are defended with many Arguments by those who maintain them are at present in vogue ; the first is, that all Particles of Matter, of what Nature soever they be, are capable of being turned into Fire, if they can but be moved swiftly enough, or can be divided small enough.

Now, whether such Motion be occasioned by that Fire Fluid, which the Followers of the famous *Cartesius* term the *first Principle*, or of something else, we shall not here enquire.

SECT. VI. *The Second Notion. Fire seems to be a particular Matter.*

THE Second Opinion laid down by other Philosophers is, that Fire is a particular Fluid Matter, like Water or Air, which, like those, adheres to many Bodies, and adds something to the Composition thereof.

What sort of Figure the Particles of Fire consist of, we shall not here attempt, as some have done, to investigate; forasmuch as it is not easie to discover the same, nor likewise, whether the Chymists have guessed any better, some of whom will have the Essence of Fire to consist in Sulphur, others in an Acid. We shall content our selves with producing the Reasons why it seems most Credible, that Fire both has, and maintains its own Essence and Figure, remaining always Fire, tho' not always Burning.

SECT.

SECT. VII. *The first Reason for the aforesaid Opinion.*

To shew this the first Reason, seems to be, that *all Matters are not Combustible.*

How happens it, that Wood and Turf will burn, but that the Ashes which they make are incapable of Burning? if it be not upon this Account, that the Fire Particles, which were before in the Wood and the Turf, fly away by Burning, leaving the Ashes bereft of them, and therefore unfit for burning.

I know very well, that those who are of the foregoing Sentiment, will answer to this, that Ashes and other Bodies, as the *Amianthus* or *Feather-Alum*, and the like, which cannot be burnt by Fire, are of too gross and heavy Parts to be put into Motion by that subtil Matter. But if that were true, it would seem to be a necessary Consequence, that the smallest and lightest Parts would without Difference, be the fittest and best disposed to produce Fire; but (not to say, that Water might therefore burn, at least, much better than Oil of Cinamon, Cloves and others, which being heavier than Water, sink down in it) why don't Volatile Salts burn? Which are so easily put into Motion, that the least Warmth is capable of making 'em evaporate into the Air, and the Parts thereof so Fine and Small, that no Glass can be shut close enough to keep them always in. And to the end, that no other Objections may be offer'd, on account of the exceeding Fineness of their Parts, it is known, that they are so Powerful and Sharp, that being only dissolved in Water, they will even destroy a Metal as hard as Copper, and turn it into a Liquid Matter. They that have a mind to make a Trial thereof, need only put a

Copper Farthing into the Spirit of *Sal-Armoniac*, in which they will find it quickly dissolved.

SECT. VIII. *The Second Reason; and an Experiment.*

Secondly, IF a very swift Motion were only necessary to reduce all Bodies to Fire, and that a particular and determinate Matter were not required thereto, how comes it to pass, that hot Water being moved more violently by blowing, is not render'd Hotter but Colder? And yet, the Air is so absolutely necessary to our Fires, that without it, they would be extinguish'd?

The truth of this is known even to Women themselves, who for that purpose cover their Fire with Covers, or shut it up in Dove Pots.

And to the End, that no Body should believe that this way of extinguishing the Fire is not so much owing to the want of Air as to the obstructing the Ascent of the Smoak, whereby it is suffocated; Let a Man make a Tube of Paper (*Tab. XVI. Fig. 2. A B C D*) the Cavity whereof must be a little larger than the Thickness of the Candle *G H*; and let him suddenly put it over the said Candle burning; now if there remains below at *C D*, any Orifice or Opening between the Candle and the said Paper Tube, so as to admit a free Passage to the Air, the Candle will keep its Flame and remain burning; but if one should compress the Paper at *E F*, so as to obstruct the Passage of the Air, the Candle will be immediately extinguished; notwithstanding that the Tube remained open all the while at *A B*, and allowed a free Passage for the Smoak. [*See this Experiment in the Works of Professor Senguerdius of Leyden.*]

SECT. IX. *The third Reason, and an Experiment.*

BUT *Thirdly*, We see yet farther, that the Air likewise is not proper or adapted in all its Parts in general, for the supplying of Fire or Flame, but that certain determinate Parts of the same are required thereto ; from whence it likewise seems to appear, that we must form a more limited Notion of Fire than to think it merely Motion of some Parts, provided the same be but swift enough, and that it is very propable, that Fire being supported by some particular Parts, does therefore consist of certain particular Parts, and therefore has a distinct Nature of its own. For which purpose, let any one make the following Experiment :

We took an eight-corner'd Bottle A D E (*Tab. XVI. Fig. 3.*) cutting off the Bottom of it, and then put a Candle set upon a flat Piece of Board under it ; the Ends of which Board D and E stood out of the Glass, that they might not be driven up into it when the Glass was let down as far as B C in the Water : And we then observed ;

I. That the Candle being lighted, remained burning as in a Lantern, while the Air flowed in by several little Holes, that it found between the Board D E, and the Glass.

II. But putting the Bottle into Water as high as B C, whereby all the Passages for the Air were stopp'd, the Candle burnt about 20 Seconds, and then went out ; because the Warmth of the Candle driving the Air out of the Mouth A, the Flame lost its Food.

III. A crooked Tin Tube H K F, which was not very large, being put into the Glass, there seemed new Air to be derived to it by the Candle,

but we found however, that after it had burnt between 21 and 22 Seconds, it went out again.

IV. To see therefore if this did not likewise happen thro' want of Air, which, as it was protruded before the Mouth A, might likewise find its Passage by the other Mouth of the Tube F K H, as soon as it was sufficiently rarified by the Warmth of the Candle, we took a Pair of Bellows L H, blowing continually fresh Air therewith into the Tube, and by the Tube into the Bottle; whereupon we observed the Candle burning as bright as ever before, whilst such blowing lasted.

V. But that which is very remarkable, was, that when instead of the Bellows we blew into the Tube at H, with the Mouth, some Air which had been a while in the Lungs, we found the Candle did not burn above ten Seconds; and consequently not near so long as when it had no fresh Air at all; this is a plain Sign, that the Air in our Lungs loses that Property which render'd it fit to feed the Flame, and that Flame and the Breath of Men seem to require the same kind of Air.

VI. This is the more confirmed, forasmuch as when we suffer'd the Air to go no farther than the Mouth, and not to descend into the Lungs, and by quick and frequent Breathings, conveyed the same into the Tube, the Candle would continue burning, tho' not so bright as when we used the Bellows, which supplied it with more and fresher Air.

VII. Having put a little Wax-light in the Place of the Candle, we found that by leaving the crooked Tube in the Bottle open, the said Light burnt 170 Seconds.

From all which it may be inferr'd with great Appearance of Truth, that the Air in general is not

not only necessary to Fire, but even, that some particular Parts thereof are only proper for it ; and consequently, if it be not easie to prove, yet it is very probable, that Fire is likewise a particular Substance or Matter. For if it had wanted nothing more than that fine Element or Principle, which some Philosophers have supposed, and besides them only some coarser Particles, be they what they will, so that they could by the said Matter only be continued in Motion ; it does not seem that either of these were wanting here, even at the time when the Candle was extinguished. For of the latter Sort, there was enough remaining in the Candle itself ; and according to these Philosophers, the other fine Matter may with less Resistance come at the Flame through the Pores of the Glass, than through the Air itself. Is this likewise by Chance, that whereas Fire does stand in need of a continual Afflux of particular Particles of the Air, the said Particles are always at Hand, and are endowed with just such a Property as will feed almost all Kinds of Fires ? How come it then, that they dare not likewise maintain, that the Aptitude of the Teeth and Spokes of a Wheel, a Clock, or a Mill, or the Wards of the Key for a Lock, which it is to open, are to be formed without the Contrivance of the Workman ? Since the Ends and Purposes for which they are used, fall infinitely short in Comparison of those great Benefits which the Aptitude of Air and Fire to each other do derive to Mankind.

SECT. X, and XI. *The Fourth Reason, and Experiments.*

IF now, *Fourthly*, we can shew by Experiments, that that which we discover in Contemplating Fire has a great Analogy and Likeness to the Effects of Water and Air, with respect to the Matters that are dissolved therein; we shall learn farther, that those Philosophers seem to come nearest to the Truth, who maintain, that Fire is a particular Matter, or a *Menstruum*, as the Chymists phrase it, capable of unbinding, that is of dividing or separating very many and almost all Bodies that are known to us; after the same manner, for instance, as Water acts upon Salt, and Aquafortis upon Iron. So that the burning of most Bodies is no otherwise performed, than by the melting of some of the Parts thereof in the Flame. For which reason, if there be many Fire-Particles in such Bodies, as Wood, Turf, or the like, they help to encrease the Flame when they are let loose by Burning; and when none of these are to be met with in Bodies, or when they can't be unbound, the Flame is not encreas'd thereby, but those Bodies are only melted and render'd fluid in the same manner as we see Ashes and Metals melted in the Fire, which don't burn, but are turned to Glafs. And as other *Menstruums* do either not dissolve some Bodies wholly, or not in a long while; so we find some, but very few, Bodies that are capable of resisting the Power of Fire after it has long operated upon 'em.

Those that desire to see some Examples of this kind of Effects of Fire, need only consult the Writings of Chymists about them; and to save them trouble, we shall present them with some few.

'Tis known, that if one put Salt of Tartar and pounded Antimony in Water together, that Salt will take hold of the Antimony in a little time, unites itself in that Menstruum with the Sulphur thereof, as the Chymists delight to call it. After the same manner we find, that the said Salt of Tartar unites itself with the Sulphur of Antimony when dissolved in Fire, as before it had partly been in Water. Now the said Chymists know, that whether Fire or Water be chosen for a *Menstruum*, a Mixture of the same Properties will result from this Salt and Antimony; and every one may see the same by putting Vinegar to both.

Thus we see the same Effects resulting indifferently from Fire and Water in other Chymical Operations; such as Coagulations, which the Chymists call Precipitations; the *Regulus Antimonii*, as an Instance thereof, which being mingled with its Sulphur in Antimony, by the means of Salt of Tartar, that unites itself in the said Sulphur, is separated from it by Fire, and sinks to the Bottom after the same manner as Steel united with the Sulphur-Copperas, when this last is dissolved in Water, and so in many other Cases.

Thus we find also, that the Flame of a Candle is always blue and transparent at Bottom, but much whiter at Top, because more Parts of the Cotten and Tallow are there mingled in the Flame, which is render'd thicker thereby; just after the same manner as when any thick Matter is mingled with the Water, which will be clearest where there is a less Quantity of such Matter, and thickest or most troubled where the Matter mostly abounds. So likewise, when you kindle a Brimstone Match, the Flame proceeding from the Brimstone will appear at first blue and transparent, but so soon as the Stick or Card which it cover'd are dissolved, the Confusion of the Parts of both Bodies

dies will render the same thicker and whiter presently.

Infinite Examples of the same kind might be produced to shew the like Effects of Fire, and the Flame thereof, as do occur in other *Menstruums*, which may also be observed in the Turf of this Country, and many other Combustible Matters. Thus is Flame tinged blue or greenish, like *Menstruums*, by Copper, as it is upon this Principle, that the Enquirers understand how to give different Colours to their Fire-Works. This seems yet farther to confirm what we have said above, namely, That Fire is to be accounted for a fluid Matter, and like other Fluids, to consist of particular Parts.

SECT. XII. *The Fifth Reason, and several Experiments.*

Fifthly, IF it be thought, that it has been justly concluded, that the Air is a particular Fluid consisting of its own determinate real Parts, only because it had an Elastick Faculty (whereas several, according to a Philosophy embraced at this time, maintained the same to be nothing else but a Collection of all kinds of Particles) why should not the same Arguments be as conclusive to hold the same of Fire too? Seeing that the Parts thereof, when put into Motion, do expand themselves with much greater Force than those of the Air. An Example of such an Expansion of Fire mingled with Water, may be seen above in *Contemplation XIX*. But a more Common Proof of the unspeakable Greatness of this expansive and rarifying Power of the Fire may be fetch'd from the Modern Mines, Mortars, Canons and other kind of Artillery, which, in the blowing up of such strong Walls and Bulwarks in the amazing swiftness of the discharged Bullets, do represent to every one the dreadful Force of the rarifying Faculty of Fire; for it is now well
enough

enough known, that these Effects (scarce to be believed by such as had never seen them) are only produced thereby.

It was with Amazement that I read the Experiment of Mr. *De Stair* ; having omitted to make the same my self, because the Glasses belonging to the Air-Pump, and which are wanted for that purpose, cannot be so easily procured in this Place: He says, in his *Physiolog. Expl.* xix. §. 121. that upon trying Red-Lead in a Glass, from whence the Air was exhausted, by the Rays of the Sun collected in a Burning-Glass, the Glased Vessel, in which the said Red-Lead was contained, burst in Pieces with a great Noise. Now he that knows, *First*, that this Red Lead consists only of the Ashes of burnt Lead, upon which a continual Flame has long acted; and, *Secondly*, that the said Lead-Ashes becomes heavier by the Operation of the Flame, and therefore is impregnated with a great many Fire-Particles, that join themselves to it (since there comes out a greater quantity of Red-Lead than there was of the common Lead put into the Fire) can he judge otherwise, than that these Fire-Particles being excited and put into Motion by the Fire of the Burning-Glass, dilated themselves, and thereby burst the Glass? From this Experiment, since the Glass was first emptied of Air, and from the first of Water, it seems that it may be inferr'd, that it is not always necessary to call to our Assistance the Force of the Air, which is then present in Mines or in Guns, in order to understand the rarefying Force of the kindled Gun-Powder, since here the whole seems to be ascribed to the Particles of Fire.

The same seems to be confirmed by the additional Experiments of Sir *Isaac Newton's* Treatise of *Optics*, p. 354. where it is said, that upon distilling a Spirit from Oil of Copperas and Salt Petre

Petre, and pouring the eighth Part of an Ounce thereof upon half as much Oil of Carraways, in a Place from whence the Air was exhausted, the Mixture presently took Fire, and burst in Pieces a Glass that contained it, of six Inches Breadth and eight Inches Heighth, just like kindled Gun-Powder: This can by no means be ascribed to the Air, because the Glass was emptied of it, wherefore the rarefying Power of the Fire must be consider'd as the Cause thereof.

SECT. XIII, and XIV. *The Sixth Reason, and an Experiment.*

FROM what has been said above, about Red-Lead, it seems, that one might infer, that as Air and Water are consolidated with Plants and Living Creatures, and help to compose the Bodies thereof, the Particles of Fire are in the same manner to be found in the Structure and Composition of many things, without any actual Burning, as Water may be in hard Horns, Bones and Wood, without rendering the same Soft or Moist: This the Chymists can witness, who have frequently distilled such Bodies, without mixing any Liquid Matter with them.

They who have ever seen how easily many Things burn, and how with a touch of the least Spark of Fire, is in an instant turned almost all of it into a dreadful and destroying Flame, will perhaps insist upon no other Proofs, to be convinced, that there are lodged in Wood, Turf, Bones, Oil and Gun-Powder, a vast Number of Fire Particles, which as soon as kindled, do all of them operate, whereas still they remain Quiet and without Motion.

But for a plainer Proof, how probable it is, that Fire itself may contribute to the Formation of solid Bodies, the Naturalists know, that there has been

been lately in the foregoing Age a certain Matter disclosed to the World, to which they give the Name of *Phosphorus* : This represents externally a solid and tractable Body, but put it into warm Water, and it will assume any Form, and retain it after 'tis Cold. So that the Makers thereof use this Method to collect a great many small Balls, in which Shape it oftentimes comes over first, into one great Piece. Now, that this Matter, if not wholly, yet for the most Part, consists of a still Fire, is plain from hence ; that if you let it lye for Years together in cold Water (as a great Quantity thereof in my Custody has lain so above ten Years) it will not burn ; but being taken out of the Water, the Warmth of a Man's Hand will presently produce a Light in it, and a Flame too, tho' not sensible, and if you spread a little of it upon the Skin of your Hand, it will seem as if a little Flame rose from it, but without Burning. But if you encrease the Warmth of this *Phosphorus* a little more, it will presently exert its Heat, and be changed into a consuming and unextinguishable Fire, burning till nothing hardly remains of it, excepting, as some say, a little Sower Liquor. I never burnt it in a great Quantity, but have found by Experience, that the Warmth of the Sun will kindle it, and that when one rubs it hard upon a Cloth, the same will take Fire ; as likewise, that when some Body had smear'd his Face over with it, that he might shine in the dark, and afterwards moving so much as to get a kind of a Sweat, it burnt all the Hair off his Head, and had like to have occasion'd much greater Mischief. But we shall speak more largely hereafter concerning this *Phosphorus*.

But that besides all this, Fire joins and fixes itself in many Bodies, has been plainly enough prov'd by Mr. *Boyle's* Experiments ; and it is affirmed by many, that the Beams of the Sun collected

lected in a Burning-Glass, and pointed for a time against Antimony, has encreased the Weight thereof.

Yea, since Fire as well as Water, Air and Earth, have been upon Enquiry, found in the Compositions of all Animals and Plants, what Reason can any one alledge, that the three last should be esteemed particular and determinate Beings any more than the first? We shall not reckon the other Properties of Fire, since this seems sufficient to prove, that it is a very particular Matter, at least that it is very probably so.

SECT. XV. *Convictions from the foregoing Observations.*

Now, whatever the Nature of Fire may be, Can any one ever fancy, with perfect Tranquility, that so Noble a Creature is found in the World by Chance, and without Design? The Beauty whereof is so great, that whereas the Ingenious Painter can imitate the Colours of all things, they are only unable to represent the Glance of Fire; the Benefit of which is so universal, that without it, the World would be deprived of Warmth, of Light, of Fertility, and be nothing but a dismal Solitary Habitation for those that dwelt upon it: Even so far, that there is hardly any thing to be found in the World, the Preparation of which for the use of Mankind, is not wholly, or for the most Part owing to Fire. Not to mention the illustrious Use thereof, by which the Enquirers into Nature have made it, as it were, one of the chiefest Keys, wherewith to unlock the most hidden Secrets of Nature. Yea, if Fire has its Existence by Chance, how can any one who believes it, deliver himself from the dreadful Apprehensions, that either by the same Chance, or by an unavoidable Concurrence of ignorant, but necessary, Causes, the
World

World may to morrow, or sooner, be deprived of Fire, and he himself condemned to perpetual Darkness, and to a most miserable Condition?

SECT. XVI. *The great Quantity of Fire in the World.*

Now if one of those Philosophers, who unhappily doubts of the greatest Truths, be forced to acknowledge by what has been said above, that hardly any Living Creature can subsist without the use of Fire; let him go on and observe, the great Abundance in which it is to be found every where; and how being at hand in almost all Matters, it does, as it were, offer itself to the Service of all Men, and is found ready without their taking hardly any trouble about it.

To shew that this is true, it will not be necessary to search for Demonstrations, nor a long Chain of Arguments in the Depths of Philosophy. We know well enough, that it is to be met with in a manner every where; as in almost all Plants, especially such as consist of Wood, and which compose whole Forests, in the most part of Animals in their Bones, in their Flesh, in their Blood, all which being dried, will burn; in so many Minerals, in Fenny Grounds, in Coals, in Brimstone, in Salt-petre, yea even in Stone itself; all which Mankind are wont to make Use of after so many Ways, when either their Profit or Pleasure require it.

SECT. XVII. *The Wisdom of him that restrains
the Power of Fire.*

NOW if all this cannot induce an obdurate Atheist to acknowledge either Wisdom or Design in the Creator, or Goodness in the gracious Giver of this Fire, let him contemplate the vast Quantity thereof that is found in the World, and the terrible Powers of the same: And then, let him tell us, whether he cannot therein discover both the Wisdom and Power of him who preserves the Earth from being destroyed by Fire. Since so raging a Matter that is to be met with in such great Plenty every where, is after so wonderful a manner bridled and restrained from exerting its Consuming Faculties, and yet so readily offers itself to the Service of every one that wants it.

That this is not a vain Imagination, is as clear as the Day; because there is not only a Quantity of Fire sufficient for all Purposes throughout the World, but even so much of it, that no Body could think thereof without Horror, if he were not assured that there were not an over-ruling Power that holds the same in his Hand.

SECT. XVIII. *An Historical Account of Fire in
the Earth.*

MOREOVER, if we look upon the Earth, how can we avoid being alarmed when we find so many Parts of it filled with Fire! In our Watry *Holland*, and even in the drained Meers and Fenns, Experience has frequently taught us, that the Vapours exhaling from the Pits and Wells of the Peasants, having been accidentally inflamed by a Candle, have miserably consumed both Men and Houses.

But

But to be yet further convinced of the Danger in which the whole Structure of this Globe is, according to all probability, on account of the Quantity and consuming Faculty of the Fire hid in the Bowels of it, we need only consult History concerning the number of Subterraneous Caverns of Fire and Burning Mountains; in which a Natural Gun-Powder, if there be not yet something more violent, does so often exert itself in all its dreadful Effects. From whence otherwise do proceed the terrible Eruptions and Eructations of Fire of the famous *Mont-Gibello* or *Ætna* in *Sicily*? By the Force of which, Stones of 300lb. Weight have been thrown out to the Distance of several Miles, and whole Rivers of Fire flowing out of it, have consumed every thing round about it. In the Year 1557, it occasion'd an Earth-quake throughout the whole Island, with the Destruction of many of the Buildings, whilst Noises, like the Discharges of the heaviest Guns, were heard, and rent the Earth; thro' the Openings of which the Fire burst out in such great Quantities, as to destroy every thing Five Leagues about this Mountain. This great Burning Mountain, according to the account of *Borelli*, does contain in Circumference at the Foot or Bottom of it, about a hundred Leagues; and there might be a whole Book writ upon the dismal Effects of it.

Had this been the only Place of the World where such a thing had happen'd, our unhappy Philosopher might still have been easie, flattering himself, that it was an uncommon Event, and that there was no Danger from thence to the whole Earth: But he won't be so easily comforted, when he finds in the Relations of all Geographers, that the like Burning Mountains are to be met with in all the Corners of the Earth.

The *Monte di Soma*, or *Vesuvius*, lying not far from *Naples*, is both now, and has been for many Ages a *Volcano* or Burning Mountain; as is *Hecla* in *Iceland*, which rages oftentimes no less than *Ætna*, vomiting out prodigious Stones with a terrible Noise.

In the Island of *Java*, not far from the Town of *Panacura*, a Mountain broke out in the Year 1586, for the first time discharging such Quantities of Burning Brimstone, that above 10000 Persons in the Country round about were destroyed therewith, and casting out great Pieces of whole Rocks as far as the said Town, accompanied with so dismal a Smoak, that the Sun was cover'd with it, and the Day almost turned into Night.

The Mount *Gonnapi*, in one of the Islands of *Buada*, that has been Burning about 17 Years, broke from the rest with a terrible Report in the Month of *April*, of the said Year 1586; throwing out a most dreadful Quantity of Burning Matter, and great Red-hot Stones, of the length of a whole Fathom, as they were found in the Sea, besides such a prodigious Number of the smaller Sort, that they render'd the Sea in a manner Unfailable, whereby the Fish were suffocated, and the Waters boiled as if they were in a Kettle with Fire under it.

There is likewise another Mountain upon the Island *Sumatra*, which smoaks and flames just like *Ætna*.

The Earth in the *Molucca* Islands casts out Fire in several Places, and frequently with a hideous Noise; especially a Mountain in *Ternate*.

In one of the *Moorish* Islands, lying 60 Leagues distant from those of the *Molucca*, there happen very often Earthquakes, with Eruptions of Fire and Ashes; and those Subterraneous Fires have so great a Strength, that they cast out glowing Stones, which appear like whole Trees; and the Rocks themselves are thereby burnt and consumed; whilst the

the Mountain which represents a frightful Flame, roars with a terrible Noise, as if there were a continual Thunder, or discharge of the greatest Cannon.

In *Japan*, and the Island about it, there are many little, and one great Burning Mountain.

In *Tandaja*, one of the *Philippine* Islands, there are found many small Fire Mountains; and one in the Island *Marindica* not far from them.

The like are found in *North America*, in the Province of *Nicaragua*; as also in *Peru* among those Mountains, that make the ridge of the *Cordillera*, near the City of *Arequipa*, there flames a Mountain continually, which causes the Inhabitants to live in a perpetual fear, least it shou'd burst some time or other and swallow up the Town. There is likewise one near the Valley *Mullahallo*, which being open'd by Fire, did cast out great Stones, and by the Cracks and Noise that it made, put even very distant People into a terrible Fright.

There be also several Burning Mountains in the District that lies on the East-side of the River *Jenniscea*, in the Country of the *Tongesi*, some Weeks Journey from the River *Oby*, according to the Relations of the *Muscovites*; as also near another Water called *Besida*.

They who desire to be farther informed of these, and other Places of the World, where Fires have formerly appeared out of the Earth and Mountains, may consult the Cosmographers and Geographers, such as *Varenius*, &c.

That which is related in the History of the Royal Academy of Sciences for the Year 1708, is particularly remarkable, namely, that near the Island *Santorini*, in the Year 1707, there sprung up a new Island from the Bottom of the Sea, in which, about the end of *August*, the Subterraneous Fires, which at first made a terrible rumbling, burst out

at last with such violent Noises, as if six or seven Pieces of great Cannon were discharged at the same time, and made continually new Rents and Openings, through which sometimes a great Quantity of Ashes, and sometimes so vast a number of little glowing Stones, were cast up into the Air, that they made a little Island near that of *Santorini*, where they frequently fell down, making it appear as if it were all on Fire: Besides that, there were frequently seen huge Burning pieces of Rocks tossed into the Air like Bombs and Carkasses, with such a Force, that they were carried seven Miles before they dropt into the Sea. The rest of these terrible Circumstances may be read in the abovemention'd Place.

SECT. XIX. *Fire in the Air, and an Experiment.*

Now if we pass from the Fire of the Earth to that of the Air; must not even the most obstinate Atheist acknowledge, that this Element is likewise full thereof; in Case he ever saw the same disturbed and put into Combustion by Thunder and Lightning, and the dreadful Effects thereof? But supposing it to be in the midst of Fine and Calm Weather, and a bright Sun-shine, yet even there could he not reflect without trembling, upon the great Quantity of Fire wherewith he is surrounded, especially, if ever he had an Opportunity to observe the Effects of great Burning Glasses, which (by only collecting the Beams of the Sun into a Place so much smaller, as the Focus is smaller than the Superficies of any such Burning-Glass) can kindle a Fire of so terrible a Heat, that in a few Minutes it will do that which our greatest Fires are not able to do in Hours, Days, yea, Months and Years; of which more largely in another Place. But to shew here, that the Air, even warmed with
a Kitchen

a Kitchen Fire, acquires a sufficient Quantity of the Heat thereof to do harm, one need only take a polished Silver or Pewter Spoon, and put the Cavity of it against the Fingers, and hold it fast with the Thumb, in such a manner that the handle of it may stick out about half way above the Forefinger. Now if you hold the back of your Hand, and the Concave part of the Spoon against the Fire, so that the Appearance, or Image of the Fire collected therein, throws a bright and enlighten'd Spot upon the Forefinger, you will find, that the Fire which is in the Air, being reflected from the Cavity of the Spoon upon the Finger, will burn the same intollerably, even whilst the Hand suffers no Inconveniency from the Fire itself, and the Air about it, and is only sensible of a moderate Heat.

But to be entirely convinced of the great Quantity of Fire in the whole Universe ; Let any Body view with Attention, the Sun and the Stars, which do not only shew themselves to us thro' Telescopes, but even to our naked Eye ; and let him consider, what a vast quantity of Light descends from them to us, which is either plain Fire itself, or at least brings along with it the most subtil Fire imaginable. And then ask such a one, whether he be not convinced of the Probability of what we have said, and particularly of this, that the Heavens likewise do contain Fires, the Number of which exceeds all Conception.

SECT. XX. *Convictions from the foregoing Observations.*

NOW to come to a Conclusion of all these Matters, let a Man seriously consider with himself of all that has been just now related concerning the Fires in the Bowels of the Earth, or those of the Air and Heavens, and let him tell us, since the Property of Fire is such, that when once put into Motion, it will kindle every thing that is capable of being burnt or inflamed, and wholly destroy the same, whether it does not appear a great Wonder to every one that argues rightly, that the Earth, with all about it, is still subsisting, than that it has not long since been entirely devoured and consumed by so many Fires as are in and round about it. Certainly, if the Volcanos or Burning Mountains that are to be found in all Corners of the World, had a Communication with each other by Subterraneous Rivers of Fire (as many think may be proved by History and Experiments) it is hardly conceivable, that it could have continued in Being to this very Day.

And consequently, that which the Christians confess, and St. Peter maintains in his Second Epistle, Ch. iii. v. 7, 10, 12. does not deserve to be so much cavill'd at and derided, as is done by some Atheists, namely, *That the Heavens and the Earth which are now, by the same word are kept in Store, reserved unto Fire against the Day of Judgment and Perdition of ungodly Men.* — in the which the Heavens shall pass away with a great Noise, and the Elements shall melt with fervent Heat; the Earth also, and the Works that are therein shall be burnt up. He repeats the same in the 12th Verse; looking for and hasting to the coming of the Day of God, wherein the Heavens being on Fire shall be dissolved, and the Elements shall melt

melt with fervent Heat. Since Nature, and the dreadful number of so many terrible Fires that are found almost every where in the Heavens, in the Air, in the Body of the Earth, and almost in every thing that it produces (as has been shewn before) ought to make every one believe, that the Destruction of all things by Fire, has long been at the Door; and that it is a certain Miracle, that the World has not sooner felt the Effects thereof.

SECT. XXI. *Convictions from restraining the Power of Fire.*

BUT after all this, add yet something more, by which a Divine and Over-ruling Power is as sensible, as if it were felt by the Hand: Can any one imagine, that it is by mere Chance, and without Wisdom, that so terrible a Creature, which by one single Spark can be put into Action, and into the most violent Motion, is bridled and curbed from doing Evil, and moreover compelled to be Beneficial to Mankind in innumerable Manners, and infinite Occasions; and that there is no Direction necessary thereto, to prevent the same from putting the whole Globe into a Conflagration, as it sometimes does several Parts thereof? Can we here discover no Goodness nor Wisdom of a Great, Mighty and Gracious Ruler, since by his Power only, this raging Matter is, as it were, imprison'd in Pitch, Oil, Brimstone, and whatever else is a proper Food for it; and that he does not suffer it to break out to the entire Destruction of all Things; that, besides this, he does not deliver to Mankind the Keys of these Prisons, which can at any time set free this tamed and chained Prisoner, and set it at full Liberty, only by rubbing one piece of Wood against another, by striking Steel upon a little Stone, by putting a very small quantity of
Fire

Fire to other combustible Matters, and in short, after infinite other ways, as often as the Service thereof is necessary? Again, if the bridling all this Fire is brought about by Chance, how can any one remain without a continual and deadly Fear, that by the same Chance, which is no more determined to one Object than to another, this imprison'd Fire might shake off its Fetters, and so produce a most miserable Destruction in the most dismal manner of every thing that stands in its way?

Let now a Philosopher, who will not admit of this, in order to be convinced, step once into a Magazine of Gun-powder, where a great Quantity of that Matter is laid up: Now if Experience had not taught him before-hand, would he have easily believed, that in such a black and unsightly heap of Grains, such an unconceivable and dreadful Quantity of Fire were hid and lock'd up, in which he could neither discover Light, nor Warmth, nor any sort of Motion? and yet, by the fall of a little Spark of Fire into this seeming unapt Matter, it would be in an instant of Time turned into a Consuming and Destroying Flame, the Violence of which would rend the Earth, and cause even remote Houses and Walls to fly up in the Air, and fall down in Heaps of Rubbish; insomuch, that the strongest Towers, nor even Rocks themselves, how solid soever, would be able to resist the Force thereof.

And to the End, that our Philosopher may not flatter himself with this poor evasive Comfort, that there are but few Magazines of such destroying Matter, and that but few People have occasion to come in the way of 'em, let 'em consult the Modern Writers of Natural History; or let him only consider with attention, the Experiments and Relations of the present and past Years; and then
the

the vast Quantity of Thunder and Lightning, and the frightful Eruptions and dreadful Havock made by so many Earthquakes and Burning Mountains, and he will undeniably be convinc'd, that it is not only in the Magazines or Mills of Powder, that he is to apprehend the Effects of Brimstone and Salt-petre, which are the Ingredients of Gun-powder; but that likewise the Air and the Earth, if they be not full of a natural Gun-powder (as some Philosophers, and not without Reason, have thought) are at least endowed with so violent and dreadful a Fire, that the Effects of it does not only equal those of Powder itself, but in innumerable Cases, does incomparably exceed it; altho' it so often appears entirely inactive.

SECT. XXII. *After what manner the Fire of the Air and Heavens is preserved.*

NOW if that Fire which is imprison'd upon the Earth in so many Places and in such various Bodies, and hinder'd from breaking out for the Destruction of all things, does discover a great and mighty Preserver; so that even an Atheist cannot or dare not promise himself one Hour's Security, if it were not an All-protecting Providence, but only unknown Laws of Nature, or mere Chance, operating indifferently this or that way that interven'd: How much more then is a Wonder-working and an Adorable Power visible from hence, that such an unconceivable Quantity of Fire can be kept up in the Air round about us, without putting every thing into a Conflagration! And not to speak of Lightning again, is it not demonstrable by the Modern Burning-Glasses, that Light itself, as it is derived to us from the Sun, being a little more closely compressed or collected, would be capable of converting the whole Globe (nothing

excepted) into a glowing Ocean, much more dreadful than that which is seen in the Glass-Houses, or in the Metal Smelting-Houses.

Now I first ask those People that cannot discover in all this a Divine Direction, to what Cause 'tis owing, that the Globe of the Earth is placed and still continued in just such a Distance from the Sun; so that the Fire thereof can only warm, enlighten and fertilize the same? And how it happens, that it is not removed to so great a Distance, as to be render'd entirely barren by Cold, or brought so near to the Sun as to be burnt up and turned into a glowing Heat thereby; Since it is plain enough, that nearer to the Sun the Light is more closely compressed in the same Space, and consequently has much greater Force in Burning? And whether it be conceivable, that among so many Millions of Places that might have been posset either by the Earth or by the Sun, in the vast space of the Universe, there is just one single Point chosen, where only it is most advantageous to this our Globe without any end or Design?

Secondly, Since, if the Light came down to our Globe so closely compressed, as it is near the Sun, the Earth would undergo a much stronger and more violent Heat than what we observe in the Focus of great Burning-Glasses, wherein, in the Space of a Minute all kind of Metals fall down in glowing Drops, let these Philosophers tell us, whether any more proper Means could have been imagined by them or others, to secure the Earth from so dreadful a Heat, than to bind the Light to such Laws, by which every thing that proceeds from one Point, is dissipated and scatter'd; inso-much, that the Right Lines, which it describes by its Beams, the farther they flow from their Source, the more distant they become continually from each other. This Dissipation or Scattering of

Light

Light, the Mathematicians express by the Term of *Diverging*, and they prove the same by numerous Experiments, by which, besides that, as we have said above, the Earth is preserved from the most dreadful Conflagration: This great and unvaluable Conveniency is conveyed to Men, that all things, and one and the same Point of many, may be seen at the same time on all Sides. Of all this, those who have no Skill at all in Opticks, may for greater Clearness consult what has been said in *Contemplation XII.*

SECT. XXIII. *All the Water in the World not sufficient to extinguish this Fire; shewn by several Experiments.*

THERE remains still to remove one Subterfuge, which seems still of use to those that deny a Divine Providence, namely, that how plentiful and how terrible soever the Fire may be which is found in and about the Earth, there is yet a sufficient Quantity of Water to preserve the same from being burnt; so that upon this occasion, it does not seem necessary to ascribe such a Preservation to a particular Favour and Foresight of GOD.

I shall not object to this, that there are even such Bodies containing such Fire-Particles within them, that can only be put into Action by Water, of which a Lime-Kiln and Mill, not many Years since, has been a sad Example, which by the breaking forth of a Sea-dyke, and overflowing of the Water till it reached the Lime, was entirely burnt down: Besides, many other Instances that may be brought from Chymistry, to prove, that a Cold Matter infused in Water, will become intollerably hot, and sometimes break out into a clear Flame: Thus Oil of Vitriol, upon putting cold Water to it, will
make

make the Glass in which they are mingled so hot; that one shall not be able to hold it in ones Hand; the same will likewise happen, by pouring cold Water upon that which remains from the Sublimation of the *Lapis Hematites*, and *Sal Armoniac*, and in many other Cases.

But it is an Experiment known to the greatest Enquirers into Nature of this Age, that Living Sulphur, mixed with Filings of Iron, and kneaded to a Dough, by the Addition of cold Water, will in a few Hours time become warm, and at last be set on Fire; touching which the *Physicks* of Mr. *Hartsoecker*, the *Opticks* of Sir *Isaac Newton*, p. 325. as also the Registers of the *Royal Academy of France*, may be consulted.

Now, whether this be one of the Causes of the Subterraneous Fires, Earthquakes, and the like Motions, we shall not here nicely enquire into; but at least it is unquestionably true, that there are Matters of such a Nature in the Earth, which, far from being secured from burning by Water, are kindled thereby, and compleatly set on Fire.

And to shew farther, that there are also certain Matters which are capable of Burning in Water itself with great Violence, without being able to be extinguished any wise thereby, we need only cast our Eyes upon that sort of Fire-Works, which first performing their Operation under, and then above the Water, do thereby represent an unextinguishable Fire. To this purpose, I find this little Experiment in my Notes, of the 29th of Oct. 1695. We took a little Cartouche or Case of that kind which they use in making little Serpents or Squibs in common Fire-Works, and filling the same with Dust of Gun-powder, without putting upon it the Cracker with Grained-Powder, we tied it to a little Stone; then it being kindled and dropt into a Glass filled with Water, we observed it

to burn under the Water, and in the dark of the Evening to give a great Light.

Now, since there is in the World much Brimstone and Salt-petre (of which Gun-powder does partly consist) when they have once taken Fire they cannot easily be extinguished by Water, which does sufficiently appear from what has been just now said; as it does likewise from the frightful Eruptions of the Subterraneous Fires, which have oftentimes burst out from the Bottom of deep Seas; of which we have given an Instance before, in the case that happen'd not long since, of the new born Island near that of *Santorini*.

SECT. XXIV. *Some Experiments about the Phosphorus.*

BESIDES the foregoing, the restless Curiosity of Chymists enquiring into the Nature of all things, has some few Years since revealed to the World a sort of Collection of Fire (of which we have already made some mention above) called the *Phosphorus*, which seems to be before scatter'd in the Air, and oftentimes in Water itself, and being prepared by the accession of any Heat may be reduced into a perfect Flame: Among several Experiments which we have made about this *Phosphorus*, I find the following upon my Notes;

I. That it has been often found, that a certain degree of Warmth was necessary to make the *Phosphorus* yield a Light or Burn:

For in the Winter, or *January* 1696, a little bit of it upon a Paper, lying upon the side of the Glass Receiver of the Air-Pump, in a place that was not Warm, was observed to give no Light; but on the contrary, some of it being put upon the Hand, it presently shined and flamed, but without doing any

any hurt. The same being repeated several times, always produced the like Effect. But being put into a little Bottle, that was made somewhat warm, it did not only burn, but remained burning, tho' the Air was quite pump'd out of the Recipient, into which it was put ; and also afterwards, when the the Air was let in again : So that it appeared from thence, that this Fire, different from many others, would equally burn with or without Air.

We likewise saw, that the same *Phosphorus* being put upon the Dust of Gun-powder, and held in a Paper at such a Distance from the Fire; as a Man may hold his hand without uneasiness, both of 'em presently took Fire : The same happens whether you use the Dust of Gun-powder, or the round Grains of it with the *Phosphorus*. From whence the foregoing Assertion, *viz.* that Warmth was necessary, does likewise seem to be proved. As likewise from hence, that upon rubbing the Phosphorus upon brown Paper and warming the same, it will burst out in a perfect Flame.

II. In another Experiment, we took some of the finest Parts, or Dust, of the Phosphorus (which in the Distilling are drawn over together with the rounder and larger Pieces) and put it into a little Vessel, with Water upon the Fire ; where after it had boiled, we perceived, that in the empty Part of that Vessel, there appeared a great Light, and a perfect, at Top of the Water, and some little Pieces, as if they were burning, floated upon it.

From hence it is plain, that these Fire-Particles, with the requisite Degree of Heat, will likewise burn in Water ; and that Fire can also pass thro' Water, and produce a Flame upon it without being extinguished therewith : It can't be objected, that there are not sufficient Pores or Passages in the Water for it, since in the foregoing Experiment, §.XXIII. when the Gun-powder burnt in the Water

ter, a thick Smoak ascended as passed thro' the whole depth of the Water.

III. We put the Water, in which the said Dust of the Phosphorus was boiled, into the Recipient of the Air-Pump, and observed that some of the small luminous Particles preserved their Light till the Glass was almost evacuated of Air; we likewise saw, that every time that the Air was pumped out of the Recipient, a great Light rise out of the Bottle that held the said boiled Matter: From whence, as well as from other Experiments, it seemed to follow, that the Fire of the Phosphorus had an Elastick Power, which exerted itself when the Pressure of the Air was lessened.

IV. The said Water being afterwards cold, and having stood about an Hour in the open Air, it was observed, that whilst it was unmoved it yielded no Light at all, nor could any Part of it be seen in the Dark, but being shaken it fired (as we speak upon this occasion) or flashed after the manner as Sea-Water does in Summer: And we found also about a Week after, that the said Water upon shaking the Glass in the Dark, did still give Light like the Water of our Ditches in a hot Summer, notwithstanding that the Glass remained always unstop'd and open. Yea, it may be inferr'd from hence, that Fire does likewise cleave to Water. And if the firing of the Sea, and of some of our Inland Salt-Waters proceeds from this Cause, that a like Matter cleaves or joins itself to them, one may likewise conclude from thence, that (how strange soever it may appear) Fire does also mingle itself with Water in a great Quantity, without being extinguished by it, if there be but the least degree of Warmth therein.

V. I must add hereto, that this Phosphorus, with which all these Experiments were made, had

lain at that time four or five Years under Water, and had been kept in the same ; so that even Water being cold, seems to be capable of serving for a proper place, to keep Fire in, and from whence the same Fire remaining unextinguished, may upon all occasions be produced.

VI. Now, whether we may from hence form an Hypothesis is, that this ignite Matter owes its birth either to the Air, or to the Rays of the Sun that are therein ; since the Urine of Animals can produce no such Phosphorus, without having been a long time exposed to the open Air and Light of the Sun, and likewise thoroughly fermented and putrified : As also, whether the Cause why this Fire cleaves to the fermenting Urine, be on account of its Saltness, so far as in other Waters also, which are salt or brackish, such Fire or Flame is commonly observed ; we are not yet ripe enough in Physical Knowledge to determine any thing about it here. This is certain, that when the Air and Light have acted a long time upon any such Matter, many Phosphorus's will proceed from thence ; and that there is a very great quantity of Fire scatter'd in the Air, which exerts itself in some manner in all Meteors, but in Lightning particularly after a dreadful manner. Now Lightning, quite contrary to the Nature of other Fires, seems to want nothing but the Heat of the Sun to kindle it ; and accordingly it is observed to be most frequent in hot Countries, and with us in warm Weather. This likewise seems to be one of the Particular of the Fire which is found in the Phosphorus, that an almost common Warmth, yea, such a one as is hardly able to kindle a Fire, or Gun-powder, will yet set the same a Burning : And when it burns, we see, that like Lightning it breaks out sometimes with several Repetitions of new Flames, as
I find

I find in my Notes, that when I held a Phosphorus in a little Bottle exactly over a burning Candle.

I don't know whether others can shew such a Fire even also a Liquid Matter that can be presently set on burning so easily as this *Phosphorus*; only by the Heat of one of our Summer Days; but I never saw any kind thereof besides this ignite Matter that appeared to me in its manner of Inflammation so analogous to that of Lightning: For as for all other ways that are made use of by the Philosophers to shew how Lightning is kindled in the Air, there seems to be either a real Burning Fire, or some other Matters supposed, which many will not allow to have place in the Air.

SECT. XXV. *A Fluid Phosphorus.*

WE find this Phosphorus useful for discovering Properties of Fire in many other Cases; and among others, it seems to serve for a Proof and Confirmation of what has been said above, §. VI, &c. namely, that Fire is a particular fluid Matter: Forasmuch as this compressed Fire in the Phosphorus will suffer itself to be dissolved in Oil of Cloves, and some other Oils, and communicate to the same some ignite Particles; so that if you let a little piece thereof lye any time in the said Oil, it will acquire a Faculty of Shining, and represent a liquid Phosphorus: At the same time however, refusing to be dissolved, and to mix itself with many other Oils and Liquors. This likewise does in some manner seem to shew that Fire, at least, that which is in the Phosphorus, does consist of a particular determinate Matter.

SECT. XXVI. *Preparation of the Phosphorus.*

I WAS not here minded to describe Chymical Processes in all their Circumstances; but to the End, that every one may be assured of the Truth of what we have here said, and have an Opportunity of enquiring farther into the Properties of Fire by the means of this ignite Matter, I shall here add a Method of making the same more convenient than those which many Chymists have left behind in their Writings. That which I find in my Chymical Observations about it, is as follows;

I took the Dregs or Settlings of Urine, that had stood a long time in a Tub in an Hospital, and had thereby acquired the Thickness of Soap; I put some Rain-Water to it, stirring it about in order to incorporate them together as much as was possible, and by pouring off the uppermost and thinnest Parts of it, I separated the other Impurities from it. Then I let it stand in the said Water so long, till the Matter that was in it did all entirely subside; from which afterwards, by the Repetition of fresh Water, all the Salts were separated. This the Chymists call *Edulcorating*, that is to say, making Sweet or Fresh. This subsided Matter being dried in an hot Iron-pot, was put into two little Retorts, and placed after such a manner in the smallest reverberating Furnace, that that which we had a mind should come over by Distillation, might not rise too high. Then next Morning, at half an hour after Six, I put Fire under it, but joyned no Recipient to it, and about half an Hour after Eight, a yellowish Matter began to come over, which dropt into two little Glasses set under it, and would make an Ebullition with Aquafortis. At one a Clock of the same day, when the Fume and yellow Drops ceased to
come

come out of the Retorts, there were two little Vessels, the Mouths of which were prepared before for that purpose, fasten'd on with Luting; being first filled with Water in such a manner, that the Orifices of the Retorts might be just above the Water; and we presently observed something like Lightning in the said Vessels. At three a Clock the Air which was in those Vessels over the Water, was glowing and red, and the Phosphorus lay at the Bottom of the said Water; the Furnace itself was made narrower than it should be for other Occasions, but the Fire-place had its entire Magnitude, to the end, that it might afford as strong a Heat as possible; and to prevent the Diminution of it by the frequent addition of fresh Turf, it was supplied at least with those burnt ones, that are used to be kept in the extinguishing Pots.

SECT. XXVII. *Convictions from the foregoing Observations.*

BUT to return to the Business: Since we see in this Phosphorus such a Fire, which upon the accession of any Warmth cannot only not be extinguished by Water, but may be kindled and burn therein; since likewise we see something of the same Nature to happen in Lightning, which, altho' surrounded by so many thick watry Clouds, yet is not hinder'd from being kindled in the midst of 'em, and from setting on Fire every thing about it: Since we see farther, that this Fire of the Air mingles itself with Salt-Waters, and in the Summer time causes them to flash and shine; and besides, makes Gun-powder and Salt-petre, when set on Fire, to burn in Water just as they would do out of it. To say nothing of the Subterraneous Fires,

that rage so terribly, tho' they lye under the deepest Sea : I say, if an Atheist would consider all these things, is it possible for him to acquiesce in so poor an Evasion as this, that the Water, when once it is put into a general Operation, can secure him either from the Etherial or Subterraneous Fires.



CONTEMPLATION XXII.

Of Beasts, Fowls and Fishes.

SECT. I. *Transition to the Beasts.*

HAVING already contemplated Mankind under so many Circumstances, namely, with respect to the Air in which we Breathe ; with respect to Water that serves us for Drink ; with respect to the Earth that yields us both Food and Dwelling ; and lastly, with respect to Fire, whereby such great things are brought about, it hardly seems credible, that any one can reflect upon all the foregoing Particulars with due Attention, without being convinced of the Existence of a wise, powerful and gracious GOD. And in Case all this be not sufficient to disengage him from his deplorable Scepticism ; let him proceed farther on with us, and silently and seriously contemplate the Beasts that inhabit the Earth, the Birds of the Air, and the Fishes of the Waters, and perhaps the Creator of all those Beings may vouchsafe to bring the Proof of his adorable Perfections, that shine forth therein,

therein, powerfully home to his Heart and Understanding.

We have already treated concerning Men, and the wonderful Structure of their Bodies (which otherwise ought to have had the first Rank here) for which reason we shall not enter farther into that Matter now ; we shall likewise pass by every thing in Beasts that have any Analogy or Likeness with Men, such as the Structure of their Bowels, Muscles, Circulation of the Blood, &c. So that after one or two General Remarks, we shall only here propose some Particulars of Birds, Fishes, and other kinds of Animals ; leaving the farther Enquiry, wherewith many large Volumes have been filled, to the Study of those that examine them with a design of Learning to know G O D from thence.

SECT. II, and III. *Concerning Tame and Wild Beasts ; and the Text in Genesis, Ch. ix. v. 2. relating to the same.*

To come then properly to the Matter ; we are wont to distinguish the Beasts into Tame and Wild : Can then any Body imagine, that he is able to prove, that it is owing to Chance, or to any Causes necessarily resulting from the Structure of Animals, that the Tame Beasts, which are so useful and serviceable to Mankind, either for Cloathing or Feeding them, or for other Purposes, such as Kine, Sheep, Horses and the rest, seem disposed by Nature to be Domestick Animals, and to live among us : Whereas the Wild, such as Lyons, Bears, Tygers, Wolves, Serpents, and the like, delight to dwell in Woods and Solitary Desarts, and of their own accord seem to avoid the Company of Men ? Now if this were quite the reverse, and the Devouring and Poisonous Creatures should

keep together in Flocks, and exert their Violence against Mankind, how much Pains and Trouble would it require in many Places to defend ourselves against their Assaults.

We ought therefore to consider with no less Amazement than Attention that Text in *Genesis* ch. ix. v. 2; where GOD says to Noah and his Sons, *The fear of you and the dread of you shall be upon every Beast of the Earth, and upon every Fowl of the Air, upon all that moveth upon the Earth, and upon all the Fishes of the Sea; into your hand are they delivered.* And to observe how many Thousands of Years this Word has continued true. Could a Man that had seen an Elephant, a Bull, or a wild Horse provoked, enraged, and then let out to do what Mischief he would (and who did not know after what manner People used to Tame these furious Animals, and many others, and render them Serviceable) ever believe the same without looking upon the above-quoted Text as a wonderful Prophecy? And not to mention Birds and Fishes (without even excepting the greatest Whales) in which the same is very plain and manifest; it is well known from a Multitude of Examples, that this has place in the most devouring and pernicious Creatures. For not to repeat what we have already said, that of their own Nature they chuse to live in Wilderesses and uninhabited Countries, we may meet with a very remarkable Evidence thereof in the *Ephemer. German.* 9th and 10th Year, p. 453. namely, that a Lyon will never assault a Man unless compelled thereto by Hunger, Self-defence, or the Discharge of a Gun against him; and in relation to Tygers, we read the following Passage; *they are afraid of white and naked Men, like* (which is very remarkable) *all Wild Beasts of Asia and Africa, and avoid them as it were a kind of Reverence; and it is without example that they attacked*

any

any such. After having understood all this, let an Infidel himself tell us, whether *Moses*, whom he must account a great Politician, would not have acted against common Prudence, when he pretended that those Words which at that time when they were spoken were so little probable, proceeded from G O D, whom he served, and whom he desired that *Israel* should likewise serve.

SECT. IV. *The Structure of Beasts in general, and Convictions from thence.*

TO come now to some Particulars: If we should contemplate all Beasts, Great and Small, Wild and Tame, and at the same time suppose, that there was but one of each kind in the World: Then should any one view with a Microscope the Structure of the least, even of the most contemptible Fly, or smallest Mite in a Cheese; cou'd he forbear acknowledging each of 'em to be a Miracle of Nature; and not be sufficiently convinced, that He who had formed all the Members of them, so useful, with respect to each other, must have been very wise; and that in providing them with a Mouth, Feet, and other Parts, he did it with a Design that they should eat and walk, and discharge other necessary Functions therewith!

It is wonderful again, that these unhappy Philosophers, seeing an Artificial Mouse or Fly, by the help of Springs and Wheels, like a Watch, enabled to perform some of the most common and rudest Motions of those Creatures, think they can never sufficiently commend the Skill and Contrivance of the Maker: And yet, when we see the Original, the living Creatures themselves, in which they are forced to confess there is infinitely more Skill and Judgment to be found, do yet maintain, that He
that

that formed them was endowed neither with Wisdom nor Understanding.

SECT. V. *Of Procreation in General.*

BUT now suppose one should shew them of each Species of Beasts, not one only, as above, but two, Male and Female, both which were endowed with Parts of Generation relative to each other, and were enabled thereby to Propagate their Kind: Let the most presumptuous and conceited Atheist, tho' never so well versed in Mathematicks or Mechanicks, propose to himself the following Problem, namely, *To make two Animals of the same Species, which besides all other Faculties of Eating, Drinking, Running, Flying, and the like, have likewise that wonderful Property of jointly producing other Creatures of their own kind, and so to continue their Posterity after their own Kind.* And let him Answer us, whether he could find himself able to do this with all his Wisdom; and if not, whether he must not esteem him that can do it for much wiser than himself, and all other Men together.

This being done, let him with us contemplate not one, not two, but thousands of such Creatures in the World; and then consider with himself, whether a pious Enquirer is so much in the wrong, when he acknowledges the adorable Glory of the Great Creator in all these things; who, to the end, that every reasonable Being, that sees these his Wonders, even in such small Creatures, may be thereby convinced of his Power, of his Wisdom, and of his Bountifulness, which he extends to the most contemptible Animals.

If this be not true, how comes it to pass that in each of the two Sexes, the respective Parts for Procreation are so accurately adapted, that among so many Millions, there is hardly one only to be found

found that is not or will not be rightly form'd for propagating his Kind. And if this were not the Design and Purpose of the Creator, what Reason can be alledged, that all kind of Creatures living, both upon the Earth, in the Air and Water, (how different soever in Nature, Figure, and Size, they may be) are hurried with so strong an Inclination, yea, even with Rage and Madness, to propagate their Species? Infomuch, that one cannot contemplate the same without Terror many times in those Creatures that are strong enough to do mischief.

SECT. VI. *Generation performed after various Manners.*

THE rather (whereby all Evasions are cut off) since the wise Creator of all things living has caused this Propagation of the Species to be performed after so many and various Ways, that whoever is endowed with any Reason or Equity, must be convinced, that all this proves in the clearest manner the Work of a free and wise Divine Pleasure, but by no means of a natural Necessity, operating always after the same manner.

Thus we see, that Men, Kine, Sheep, and numberless other Creatures, are received and formed in their Mothers Body.

That most Birds are indeed received in their Mothers Body, but are formed in an Egg out of the same.

That many Fishes (as the Experience of Fishers and other Enquirers inform us) are not only shaped, but likewise received out of their Mothers Body; forasmuch as the Female or Spawn-Fishes, discharging their Spawn in convenient Places in the Water, the Males resort thither and impregnate the same; whereby the little Eggs in the Spawn
are

are fecundated, and Fishes of the same Kind are produced from thence.

The First is performed entirely in an Animal and Liquid Warmth.

The Second, so far as it relates to the Reception, is after the same manner; but the Formation is in a dry and different Warmth: So that in some Countries many Chickens are hatched from Eggs, in Ovens made expressly for that Purpose; not to take notice that Women likewise have hatched Chickens from Eggs by the Warmth of their Bosoms.

The Third, concerning Fishes, happens both ways in Cold Water, without any remarkably Warmth.

And besides this, to shew that the Great Ruler of all things will not suffer himself to be bound by any Necessity or Fatality, we may see other Fishes to be received likewise in their Mothers Body, such as Carps, the Spawning-time of which is well known to the Fishers that testify the same. But besides these, there are other Fishes likewise formed in their Mothers Body, such as Whales, Hagen, &c. in which People have oftentimes found living Young ones of the same Species.

SECT. VII. *Animals of both Sexes.*

BUT farther to prove this last, and the unlimited Will of the great Creator of all things in the Execution of his own wise Purposes, could it be believed that there is a Species of Creatures, which are at the same time both Male and Female, and which do copulate with each other after both ways? They that desire to be satisfied therein, may consult the *History of the French Academy* for the Year 1699. p. 46, 47, &c. where Mr. Poupart affirms, that he had observed it in Worms that are in the Earth, which would get into a proper
Hole

Hole for that purpose, by two and two, after such Manner, that they can stretch themselves strait out by each other, placing the Head of one by the Tail of the other ; after which manner they Copulate, and have been so found in Spring in warm and moist Weather. This has caused Mr. *Hombert* to doubt, whether this Kind of Worms might not impregnate themselves, since they can conveniently bend their Bodies, and become Males at one end and Females at the other, into which we shall not farther enquire. Mr. *Poupart* does likewise give us there a rough Enumeration of those Creatures, in which he says, he is sure, that this Particular has Place ; and besides these Earth-Worms, there is mention made of another kind, with round Tails, which are found in the Intestines of Men ; so likewise such as are found in Horses ; the Snails of the Earth, and of Fresh Waters, together with many other Kinds, and all Leeches and Blood-Suckers.

This Observation is likewise confirmed in the said History, for the Year 1708, with many Circumstances about Snails, by Mr. *du Verney*, as also by Dr. *Lister*, in his *Anatomical Excercitations*, as they are mention'd in the *Act. Lips.* 1695, p. 318 ; and Mr. *Blancart*, in the *Theatre of Rupsen*, relates the Observations of *Swammerdam*, concerning the Coition of the Horn-Snails, who have in their Neck both the Parts of Generations by each other, and are wont to brandish the Male *Virga* several times, till it can meet with the Female Part of the other, on both sides the *Tab. XVI. Fig. 4.* will shew this without farther Explanation.

SECT. VIII. *Convictions from the foregoing Observations.*

I HOPE there will be no occasion here of using many Arguments to convince a Sceptick, that one who acknowledges a GOD, will not maintain so absurdly, when he sees that one and the same End of Generation is performed after so different Manners (each of which is full of a wonderful Wisdom) that this whole Work is to be ascribed to mere Chance, by reason of the Skill and Contrivance appearing therein ; Nor yet to a blind and ignorant necessary Cause, on account of the Diversity and Variety whereby the same End is so wisely pursued : But much rather attribute it entirely to GOD, who being neither limited by Laws, by Methods, nor by Instruments, in revealing his Wonders to Mankind, does make every thing according to his own good Pleasure, and the Council of his Will.

SECT. IX. *Young ones produced upon the back of a Pipal.*

NOW, after how many different Manners, besides those already mention'd, the Production of Living Creatures into the World is performed, may be seen in those Treatises that have expressly handled this Matter : And that we may be once again convinced, that this is only to be ascribed to a Supreme Will, directing all things according to its determinate Purposes, and which is bound by no particular Rules, we may contemplate the Production of *Caterpillars, Silk-Worms*, and the like, and observe how much they differ therein from other Creatures, being not fit for it before that they

they are entirely and specifically changed, and from creeping become flying Creatures.

Besides all this, the Belly of the Female Animals seems to be the principally designed Part for the Procreation of their Young ; but again, because none should imagine that this were an absolute Necessity, and to be ascribed only to the unknown Laws of Nature, let him consult the Second and Third Figure in the Fourth Table of the *First Cabinet of Animals*, of Mr *Ruyssch*, where, to his great Astonishment, without doubt, he will find an *American* Animal, called the *Pipal*, like a Toad, which produces its Young ones out of its Back ; so that neither those Creatures, nor the Eggs from whence they come, have any Communication with the Cavity of the Belly.

SECT. X. *The Food of Animals.*

AND to the end, that it may not be thought that the Generation of Animals is not just the only thing in which the Wisdom of the Maker shines out equally with his Free Will and Pleasure, by which he does all things to his own Glory, and to the Confusion of those who represent his unbounded Power by the Likeness of a Clock, or other Artificial Machine that Works necessarily and ignorantly ; Let the Atheist contemplate those Parts of Animals that are useful to them in Feeding ; and let him observe particularly how Kine, and other Beasts that have no Teeth above, and upon that account can't chew their Meat small enough at once, are provided with a Maw, in which the Grass they swallow is thoroughly moisten'd, to the end, that when it is brought up again into the Mouth, being Softer and Mellowed, it may be render'd as small as is necessary by a second Mastication, which is called
chewing

chewing the Cud ; and how, after having been swallowed the second Time, it descends into other Ventracles or Bowels, where it is first turned to a proper Chyle in order to nourish them ; concerning which those who have expressly written may be consulted. Thus also there are some other Animals fed with Grass, that do not serve for Food to others. In the Dutchy of *Crain* in *Austrea*, there are found black Snails as big as ones Fist, and not inferior in tast to Oysters, living in the midst of a very hard Rock, which must be broke in pieces to come at them. Let any one guess how, and with what these Creatures are nourished. But I only ask this Question, *first*, Whether it can be supposed to happen by Chance, or without Wisdom, that these Cud-chewing Animals, which are deprived of an upper Row of Teeth, are furnished with such a particular Manner of Digestion, and that Dogs, Swine, and all kind of Fowl that do not want it, are not provided with the same. And, *Secondly*, Whether it does not fully appear from thence, that he who has given to all Animals the proper Instruments for Feeding, is not bound by any necessary Laws of Nature, which tending all to the same Purpose, do always act after the same Manner.

SECT. XI. *The Motions of Animals in General.*

THE same does likewise appear from the Diversity of Motions in Animals, whereby they pass from one place to another. Thus most Birds, both small and great, have Feet for Running and Wings for Flying ; Fishes have no Feet but Tails and Finns for Swimming ; some Beasts have two, some four, others more Feet for Running ; others having neither Feet nor Wings, do
creep ;

Fig. 2.

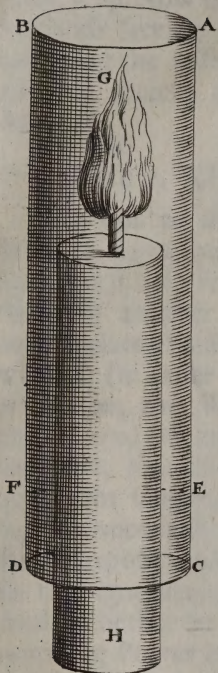


Fig. 1.

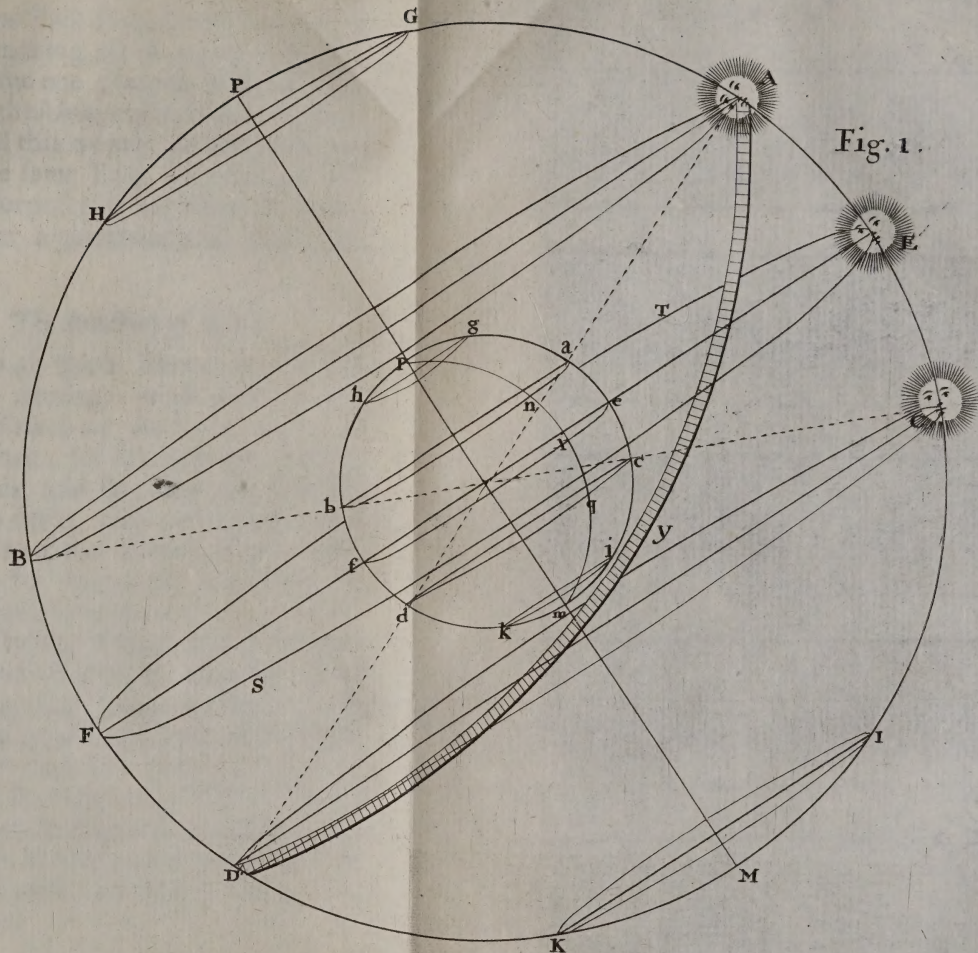


Fig. 4.

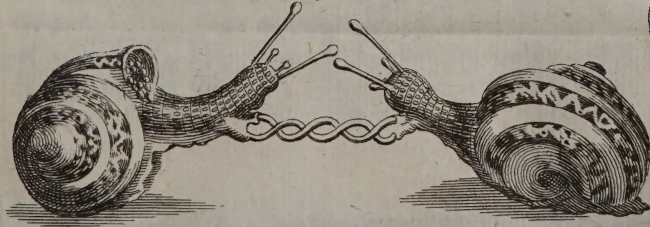
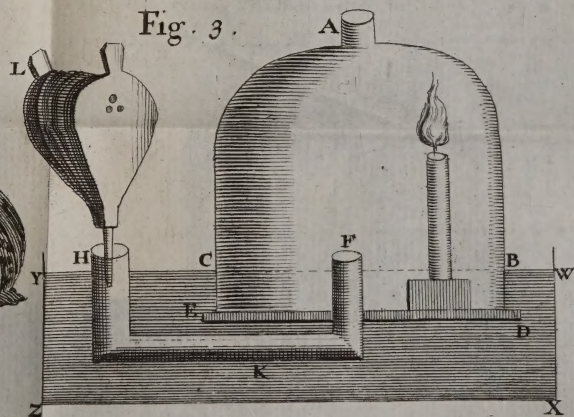
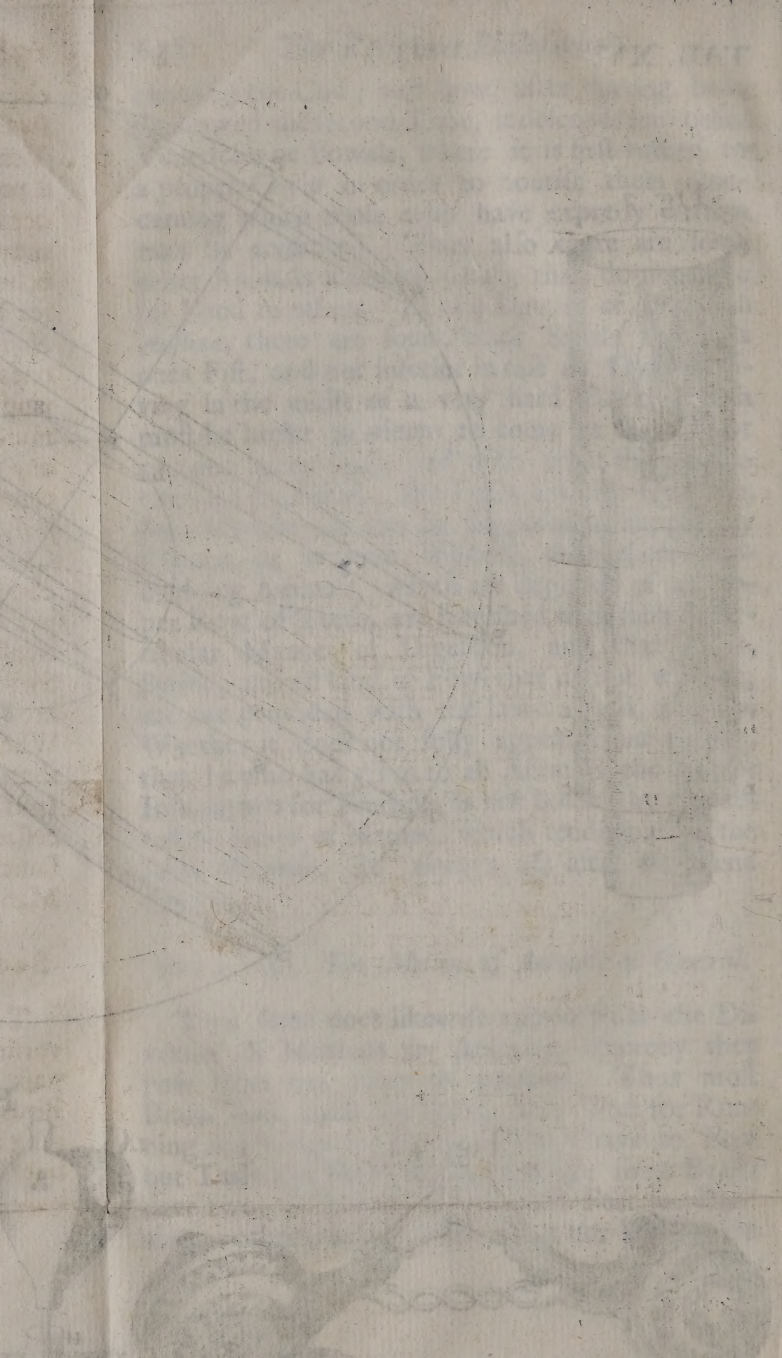


Fig. 3.





creep ; others, as some Shell-Fish, draw themselves along by Threads, making use of a quite different manner in moving from one place to another. See concerning the same, the *Memoirs of the French Academy*, 1706, p. 69. Now in all this we may observe different Methods serving the same End, and each of 'em executing the wise Purposes of the Creator, being adapted thereto after a particular and wonderful Manner.

SECT. XII. *The Structure of Birds.*

AND not to stop at those Particulars which seem to have some Analogy with those of the Humane Kind, forasmuch as we have treated of them in another place ; let the unhappy Atheist contemplate the Birds, and let him ask himself, whether (in order to deny, with some appearance of Reason, the Wisdom and Power of an adorable GOD) he can be contented necessarily to conclude, that all those Instruments which are requisite for Going, Flying, Eating and Procreating, so necessarily and so artfully adapted to all these Purposes, are owing to mere Chance, and to the ignorant and necessary Laws of Nature : And, whether he can conceive, that without an overruling Power and Providence, a Bird so wisely form'd for Flying, not to speak of other Faculties, can have acquired its Existence out of that Matter and Substance, with which an Egg is filled, only by a brooding Heat ?

SECT. XIII. *The hollow Tubes or Bones of a Bird.*

LET him first contemplate the little Bones of a Bird, and he'll find those of their Legs to be much hollower, as well as the Substance of them much thinner, than those of other Creatures ; the reason of which is, that the Bird may be lighter, and so more fit for Flying. But to the end, that the

Thinness of it should not render it weaker, it seems necessary, that the Substance of the Bone itself shou'd be harder and stronger than in those in other Animals. Now if we consult the Observations of those that have inquired into it, we shall find it to be so in Fact. Will then our unhappily blind Philosopher maintain, that this also comes to pass without Wisdom and Design?

SECT. XIV. *The Cartilages in the Joints; and Convictions from thence.*

MOREOVER, let any one who has, for instance, a Pullet upon his Table, examine the same, and see how in that, as in other Animals (of which something has been said before in *Contemplation* XI. §. VIII.) the ends of these little Legs are encompassed with a smooth or polished Cartilage, to move and bend the same conveniently; some are moved by means of a round Cavity, which is likewise clad with a Cartilage, and others by means of two circular Protuberances in two like Cavities adapted thereto: Let him afterwards attentively view the little Joints in the Claws of such a Pullet, and he will find, that here likewise, as well as in the great Bones of the largest Ox, the Extremities of these so small Bones are encompass'd with smooth Cartilages, to the end, that in the Motion of them, one Bone may slide upon the other more easily, and the proper Motions performed in every Part without any Obstruction.

Now if there be not a wise Contrivance in this whole Structure, why are not all the Bones (which would be then too weak) composed of mere Cartilages only? Why do they occur in those Parts alone, where by their Smoothness they render the Motion more Light and Serviceable? Why is one end of the Leg Spherical, or exactly round

round, where it is necessary to be moved not only forwards and backwards, but also Sidewise? and at the other end, where there is no occasion for such lateral Motion, there are two such Protuberances formed, as to hinder it from being inflected otherwise than Backwards or Forwards? He who sees all these things, and so many others, which can only serve for their particular Uses, and shall judge, that they have acquired such a Disposition without Wisdom and Design; why may he not as well in reading a Book or a News-Paper, affirm, that all the Letters are ranged in the Form he finds them in by mere Chance likewise, and without any Design of the Printer?

SECT. XV. *How the Wings are moved in Flying.*

BUT now if we carefully observe, first, after what manner the Birds fly and make use of their Wings for that Purpose; and next, how these Wings are made and put together, so that no Man living could have contrived 'em so artificially, and prepared 'em for Service; I am not without Hope, that this may convince, if not all, yet at least some Sceptical Minds, and oblige 'em to confess, that Wings are as much given to Birds for the end of Flying, as the Hand of a Watch is made for shewing the Hours.

To be satisfied of it, let us remark, that a Bird moving its Wings does not strike them from the fore Part backwards, nor use them like Oars, after which manner they would very much obstruct the Action of Flying; since being brought forwards with so much Swiftnes, they would strike against the Air, and so either drive the Bird backwards, or at least hinder its proceeding forwards: Forasmuch as their Structure is quite different from that of the Claws of Geese, Swans and Ducks, &c.

which, because it has pleased the Creator, that these kinds of Fowls should make use of the same as of the Oars of a Boat, their Wings are of an entirely different Structure, of which hereafter. And in case any Progress could be made by the Birds through the Air after this manner, yet the Bird itself by being heavier than so much Air, would fall down, or at least sink leisurely downwards. But not to dwell too long upon Arguments only, we need only observe for a Proof what has been said, that great Birds, such as Ostriches, Storks and Swans (in which, by reason of the slow Motion of their Wings, the same may be clearly seen) in Flying strike their Wings up and down (or perpendicularly upon the Horizon, to speak like a Mathematician) whereby we find, that the Bird is at the same time supported and moves forwards in the Air.

Can we then perceive no Wisdom herein ! That these Wings (*Tab. XVII. Fig. 1.*) A E and B F, of the flying Fowl B G A, are somewhat hollow below, in order to take hold of the Air with so much more Force and Power in striking them down ; and above they are Convex, that in lifting 'em up they may meet with the less Resistance from the Air ; and so that they mayn't lose in the upper Stroak of their Wings that which they gain'd in the lower, to keep them floating in the Air. But that which is here particularly to be observed, is that these Wings are not fasten'd to the Body by their whole Breadth, but only at A and B, all the other Parts thereof being entirely loose ; whereby it happens, that (as may be seen in the Observations of *Borelli, Prop. CLXXXIII, and CLXXXIV.*) the said Wings being raised up, do only cut the Air upwards with the sharp Forepart A E and B F, that they may meet with less Resistance ; but striking the Air downwards with
a greater

a greater Swiftness, they describe with all their Points, Lines that are almost circular, such as EIP and FVL.

But since the wonderful Manner whereby a Bird cuts the Air with his Wings upwards and downwards, and moves them forwards at the same time with so great a Velocity, cannot so easily be described nor comprehended by Words; let us represent to ourselves, in *Tab. XVII. Fig. 2.* a Bird RS, as he floats in the Air and extends both his Wings BEA and BCF, we may then suppose, that when these Wings are moved directly downwards, the Arms thereof, BC and BE, which being composed of Bone, and therefore stiff and hard enough, do describe two Circles whose Planes make Right Angles with the Horizon, as in the foregoing *Fig. 1. Tab. XVII.* and so cause the whole Wing to follow that Motion, and to exert its Force with this perpendicular Blow upon the Air that lies under it, HGBEA.

Now, forasmuch as this Air when smitten by the Concave Superficies of the said Wing, makes a Resistance (as it happens when Women move their Fans through the Air) because it cannot recede quick enough: And moreover, as the Parts of the Air being compressed by the Velocity of the blow, do sensibly endeavour to expand agen, as we have sufficiently proved above in *Contemplation XVII.* about the Elasticity of the Air; and as appears plain enough from the rushing Noise which Birds make by flying or stirring their Wings; it will follow, that the Feathers EAO, by the said Resistance and Elasticity of the Air, will bend upwards, being made of a flexible Matter; and therefore when the Arms BE and BC, composed of an inflexible Bone, pursue their way in striking downwards, the Ends of their Wings A and E, will

by the upper bending of the Feathers, be pressed towards each other.

From hence it is easie to see, that the Air being beaten downwards by the Wings, and by its Elasticity resisting upwards, the Bird is supported in it by the repeated Reverberation at every Blow. And forasmuch as by the up and downward Flection of the Feathers of the Wing, the Air receives the Blow obliquely in the Motion thereof, we may from thence give the reason why the Bird is thereby pushed forwards, and horizontally towards R, and so is said to perform the Action of Flying. So that the beginning of the perpendicular striking upon the Air does chiefly support the Bird, and the Continuation of the said Blow does chiefly promote the Bird's progressive Motion.

Perhaps this may be render'd more intelligible to some, by supposing, as *Borellus* does, that the Bird, R S, is quiet, and without Motion, and that it holds its Wings, B E A and C C F, Level; and that by a Wind, H G O, blowing directly upwards against the said Wings, their Ends A and D being bent towards each other upon the Back of the Bird, the two Wings do thereby represent the Figure of a Chizel running obliquely into the Points A F. Now if both the Sides of this Wing-Chizel are pressed on both Sides by the opening Air or Wind, every one knows that it must follow from thence, that it will be protruded towards its broadest Part C B E, and so carry with it the Bird R S, which is fasten'd to it at R. Now those that understand Mechanicks, know well enough, that the same Effect will be produced, whether the Air be moved upwards as a Wind, or the Wing downwards.

I wish I could here substitute any known Machine proper to shew the true manner of the Action of the
Wings

Wings, and to give a greater light to the Unexperienced, how the exactly circular striking down of the Arms or Bones that are in the Wings joined to the upward Flection of the Feathers, can at the same time support a Bird in the Air, and cause him to fly forwards. But I must own I know of none my self, nor find any such in others.

Something like it, tho' very imperfect, occurs in the Tails of our Wind-Mills, as also in Ships that sail with a side or half Wind; which however only shews how the Wind blowing from one Point causes the Sails of a Mill or a Ship to move forwards towards one another: This happens in some manner likewise to the Wings of a Bird when it flies, but does however by no means represent the true Manner of Flying.

Yet to suggest something that has a little more Analogy with the Motion of the Wings; let half a Sheet of Paper be fasten'd to a little stick in the same manner as the Colours are fasten'd to an Ensign's Staff; the said Stick is to represent the Arm or Bone of the Wing, and the flat Paper the Feathers which must not hang down under the Stick, but be held up in the Air by it. Now if you move this Stick with your Hand in a direct circular Motion from above to below, and the same be done pretty swiftly; you will see, that the Paper is thereby moved, first from beneath upwards, and next from backwards forwards, from whence one may form a rough Conception (since the same thing happens in each of the Wings on both sides of the Bird by the striking down of the Arm) how the Bird moves upwards and forwards at the same time; in which Flying consists.

SECT. XVI. *The Wonderful Structure of the Wings.*

NOW whoever has attentively consider'd the foregoing, and understands what we have here said about the Action of Flying, will see, that in order to make a Bird fly, the Feathers of his Wings must necessarily be, *First*, Light, that they may not obstruct nor incumber him; *Secondly*, Flexible; and *Thirdly*, Stiff and Elastical; that is, that being bent they may resume their natural State by springing back of themselves.

Now let us Contemplate the same just as we observe them in Birds, and we shall find;

I. That the Quills to which the Feathers are fasten'd are hollow, that they may be light, and nevertheless stiff and hard, as being compos'd of a thin and horny Substance.

II. The remaining or lower Part of the Quill must not be inflexible, because in striking down of the Wing it was necessary that it should be capable of Inflection by the Resistance of the Air, to the end, as we have said before, that the two Wings might approach each other in order to meet the Air obliquely, and protrude the Bird forwards. Now we find that this part of the Quill is filled with a Matter that is very flexible and light, and which seems to me to be found no where else but there, as indeed it is there only necessary, for it does not seem reducible either to Bone, Flesh, Membrane or Tendon, or indeed to any kind of Parts that occur in these or other Animals. Now can any one pretend, that this is also to be ascribed to Chance or Ignorant Causes?

III. Now

III. Now it is not enough that these Quills should be flexible, for so is a Rope too; but it is moreover requisite, that in the perpendicular Motion of the Wings they should be stiff and hard enough too, to act with some Force upon the Air, and that being bent upwards by such Acting, they may in the lifting up of the Wing resume their former and Concave Figure.

Now all this concurs in the Structure of the Quill, for in the external Circular Part thereof it is cover'd with a Bark, which is in some measure hard, and under that, in the Cavity of it, there run two long protuberant Lines of the same Matter, parallel with each other (as is visible in a Writing-pen) covering and encompassing the afore-said wonderful Matter, like Marrow in Bones: Now that they become hereby stiff, flexible and elastical, will be obvious enough, by bending them a little, and then letting 'em go suddenly again.

IV. But to the end, that the Air may not soak thro' these Quills, and so render the Force of the Wings vain, there are lateral or cross Fibres placed in the Feather on the sides, which do not only exert each of 'em their Elastick Faculty, as fine and small as they are, but do likewise adhere together, in order to prevent any Passage of the Air. Now since this can have no Place in the Quills where there should be Pores or Orifices, we find those Interstices cover'd with little Feathers that grow continually smaller, like the Scales of Fish, lying upon each other, whereby they do sufficiently hinder any Passages of the Air between the Quills.

Now, notwithstanding all these Functions and Uses, every Feather is so disposed, that it may not obstruct the Bird in Flying, that nothing can
more

more verifie the Proverb, *as light as a Feather*, than such a Disposition.

Now with how great Art even the smallest Fibres are formed therein, may appear from hence, that each of 'em has again the same Structure as a large Quill or Feather, and does likewise consist of a Body passing thro' the middle of 'em, and little Fibres on the Sides; to be convinced of this, we need only examine a small Particle of one of these little Feathers with a good Microscope.

SECT. XVII. *Convictions from the foregoing Observations.*

CAN any one imagine, after all this, that a single Feather (to go no farther at present) has without any End or Wisdom, acquired its Structure, its Hardness, and at the same time its Elastic Power, its peculiar Substance and Lightness, its Disposition and its Place, just in that Part of the Wing where it can be serviceable, and all other Properties necessary for the Action of Flying!

At least a Christian, who has seriously consider'd the aforesaid Texture of the Feathers and the Wings which they compose, will be thereby convinced, that JEHOVAH does justly number these things among his Wonders; *Job. xxxix. v. 13.* And that a Consideration of the Beauty and wonderful Structure of those Wings, if of use to represent the Smallness of Man's Wisdom and Power in comparison of the Greatness of God's; appears from this Question; *Gavest thou the goodly Wings unto the Peacocks? or Wings and Feathers unto the Ostrich?*

SECT. XVIII. *Other Reflections upon the Structure of Birds.*

MANY more Remarks might be here made concerning the Structure of Birds: He that has ever seen how some little Birds that are wont to make their Nests in Thorny Hedges, are furnished with a particular Membrane with which they can cover their Eyes, and preserve them from being pricked in their swift Passage through those Thorns; and that such Membranes are therefore transparent, like the Eye-lids of many other Creatures, to the end, that they mayn't be quite depriv'd of their Sight, will he obstinately affirm, that this happens just to those Birds that want the same, without any End or Design?

If one considers the Structure of the Legs of many Birds, especially of such as are used to support themselves upon the Branches and Twigs of Trees; can he imagine, that it is without Wisdom! *First*, that (*Tab. XVII. Fig. 3.*) a Muscle HC , runs along the Thigh-bone BC from H , the Tendon of which IK , which contracts the Claws of the Feet of the Bird, extends itself about the Angle BIK , which Angle the Thigh-bone HC makes with the following CD : And to the end that they mayn't be displaced by Motion, they are carried on there thro' a Tube or Sheath, as *Borelli* affirms, §. 149. who has examined into the same in Eagles, Hawks, Swans and others. *Secondly*, That other Muscles, as KC , which are likewise useful in shutting the Claws EG , are united by their Tendons at K , with the foregoing IK , and encompass the other Angle CDE , and from thence extend themselves along DEG , in smooth Tubes, (that seem to be only made for this Purpose) to the Nails of the Claws at E and G .
Thirdly,

Thirdly, that when these Bones BI, ID, DE, make a right Line, the Tendons are not expanded, and therefore the Claws of the Feet remain spread in the Figure of a Star. But, *Fourthly*, the Bones B C D E, forming acute Angles, and being as it were forced to lie upon each other, that then this Tendon being stretched, the Claws of the Bird are shut close thereby, and drawn together as it were like a Fist; insomuch that *Borelli* vouches, that he could not without a great deal of Pains, thrust a sharp Stick between the closed and contracted Claws of an Eagle or a Hawk that were already dead.

A common Experiment is usually made, by laying a dead Pullet on its back upon a Table, and stretching the Feet streight out; at which time one shall see that the Claws will be extended and again contracted by pressing the Thighs and Legs against the Body; and then putting the Finger between the Claws, one shall easily perceive, that by such Inflection they are strongly enough closed together to keep so fast a hold upon the Twig or Branch upon which they sleep, without the Assistance of any other Muscles, that they can abide there without any Danger of Falling. And from hence likewise the Reason is plain, why this sort of Fowl, as often as they advance their Legs strait forwards, extend their Claws like Rays of a Circle, in order by the greater Breadth of 'em to tread more firmly, which, without using any particular Muscles thereto, results only from the Structure of the Foot, and yet is of very great use for this Creature to walk conveniently. One may make the same tryal upon dead Sparrows and other little Birds, if one would take the trouble of Examining them.

Lastly,

Lastly, To draw a Conclusion from the whole ; Can any body think that all this Disposition in the Tendons, whereby the Claws are moved, is without any particular Design? the rather, since even the flying Bird R S, resting it self upon the slender Branch F G, can, according to this Supposition, sleep safely without Fear of falling, tho' their Muscles should not act in Sleep as the same is proper to all Beasts ; for when the Bird R S having thrust its Head backwards upon its Body O, and thereby brought the same to an Equilibrium at its Feet, rests with the sharp Part of its Breast-bone upon the Twig, if the Motion of the Wind or any other Accident should put him in Danger of falling, the strong Contraction of his Claws upon the same Twig, comes to his Assistance, just as if the Twig were held fast by two stiff compressed Knippers ; for that such Contraction is performed with much Strength only by the Bird's sitting down, and by bending B C D E with its Weight upon each other, is already demonstrated by *Borelli*, and by the aforesaid Experiments. And to any one that has but Eyes to observe the Care and Providence of God over all his Creatures, and even for the Birds themselves, this seems to be a particular and palpable Demonstration of his great Goodness and Wisdom, who has bestow'd upon these Animals such a Structure with respect to their Bones, Muscles and Tendons, as that without any Pains on their Part, or once waking from their Sleep, their own Weight and Figure preserves them from falling, in such Circumstances that no body could imagine that they could remain one Minute upon the Twig at the least Motion thereof.

SECT. XIX. *The Feet of Water-Fowl.*

LET no Body think, that forasmuch as this Pinching or Contraction of the Claws, is likewise found in some Birds that live both upon Land and Water, as Swans, the same happens by chance or by other necessary Laws, because these Birds are seldom observed to sit upon Trees, and therefore have little or no occasion for such a Structure of their Feet; for if it be considered that Ducks, Geese, and Swans, make use of their Feet in swimming, as Men do of Oars; and that their Feet are of such a Figure, that being thrust out backwards, they are expanded likewise by the Resistance of the Water, and so exert a greater Force in the Progression of the Bird; we may likewise see at the same Time, that if these Feet, in their whole Breadth were to have been drawn forwards, it would have driven the Bird as much backwards; for which reason then the Contraction of their Feet (as may be observed in Womens Fans, but after another Manner) is necessary to them, to the End that they might strike out their Feet without giving the Water too great a hold of them: Now this happens in them likewise by those Tendons which, when they bend their Legs upwards, draw their Claws together, and only by this Structure, without being obliged to make any particular Motion thereto. This Experiment may, like the former, be tried upon a dead Duck or a Teal.

SECT. XX. *The Tails of Birds.*

BUT after having said thus much concerning the Structure and Use of the Wings, let us add a Word or two more about the Action of Flying,
of

of which we have already said something, so far as may relate to the horizontal Motion thereof. The Structure of a Bird, if there had been nothing more in it than what we have already consider'd, would have been a wonderful and irrefragable Proof of the Wisdom of GOD; but how much more surprising is it still, when we contemplate another Part that he has bestowed upon these Creatures to enable them to fly perpendicularly, that is to say, directly upwards or downwards, I mean the Tail, which is to them as the Rudder to a Ship; this the Bird raises at B H, when it moves upwards according to the Line B F; and when downwards, it lowers it to B I; for that it does not serve, or at least not commonly, in a lateral Motion to the right or left, is plain, from the Structure thereof. The farther Reasons may be seen in *Borelli*, Prop. CXCVIII and CXCIX; who teaches us (as well as Observation and Experience) that when Birds which fly horizontally, without rising or falling, have a Mind to turn themselves nimbly to the right or left, they move the Wing of the opposite Side more strongly, and after an uncommon Manner, as a Man uses his Arm and Hand when he would turn himself in swimming; tho' such Birds as thrust out backwards long and slender Legs in flying, do seem likewise to use the same as a Rudder when they turn to the one Side or the other.

There still remains something which does as it were appear wonderful to those that consider it; namely, how it is possible that swift flying Birds that descend perpendicularly from any great height, do not fall flat upon the Ground at once, the rather, since the swiftness of their Fall seems to be then increased by the weight of their Bodies: Now they that have ever seen how artfully they use their Wings to moderate and stop their progressive,

gressive Motion, and how they spread their Tails, must at least acknowledge that they are admirably provided with every Thing necessary for Flying, and for the various Uses of their Wings and Tails.

SECT XXI. *The Center of Gravity and Force of the Muscles of the Wings.*

NOW after all that has been said, I shall not dwell upon that wonderful Structure which Mathematicians observe in Birds with Astonishment; whereby their Center of Gravity always remains in their Breast below the Rise of their Wings, and which alone enables them, whilst floating in the Air, without any manner of trouble, to dispose their Wings, Legs, and other Joints for the most convenient Uses. Thus we see that the strong Muscles with which they move their Wings, are inserted in their Breast; insomuch that even that Muscle which raises the Wings, and which one should otherwise have expected to have found in the Back, is likewise seated in the Breast, and is carried thro' a Hole expressly made for it after a wonderful manner into the Legs, in order to perform its Function: Concerning which, see the forementioned *Borelli, Prop. CLXXXIV.* where besides what has been already said, those that please to consult that learned Work, will find a great deal more to convince them of the adorable Wisdom of him that has created all kinds of Animals.

TO Instance in one Thing that seems almost incredible; Could any one imagine that the force of the Muscles whereby the Wings are moved, is ten thousand times greater than the Weight of the Bird that flies with those Wings; and if one desires to be more fully satisfy'd thereof, with an intent

intent to admire the greatness of the Creator, he need but consult the aforesaid Author, *Prop. CLXXXIII, and CLXXXIV.* We have already given a brief Demonstration of the amazing strength of the Muscles of Men, so that this will not seem incredible to such as understand what has been there represented.

SECT. XXII. *Convictions from the foregoing Observations.*

I NOW ask again, whether any one (that reflects upon all that has been here said about Birds, and comprehends how many Things concur to the same End, and to the most proper Purposes within so small a compass as that of a contemptible Bird) can imagine, that this Creature is formed without Wisdom, and disposed as he finds it in all its Circumstances. Let him view with this Knowledge a Sparrow, a Finch, a Canary-bird, or any other of those little Creatures, and then ask himself, whether it be conceivable, that in so little Matter of so light an Animal, such numberless Instruments were found by Chance ; of which some of 'em serve for Eating, for digesting their Food, in a word, for Nourishment ; others for Generation ; some for Walking, others for Flying, and all of 'em so exactly adapted to their particular Ends, that the most learned Mathematicians and Naturalists of this Age, that have taken the trouble to enquire into the same, have very often expressed themselves thereupon with Wonder and Astonishment.

SECT. XXIII. *The Preservation of Birds.*

Now, as the Wisdom of the Creator shines forth in the Structure of the Birds, so likewise his Providence and Goodness in preserving many of them, is not less clearly manifested. The great Saviour of the World endeavouring to dissuade his Disciples from taking too great care for Food and Raiment, mentions these Creatures for a Proof of what he would have them understand thereby ; these are his Words : *Matth. vi. 25, 26. Take no thought for your Life, what ye shall eat, or what ye shall drink ;——Behold the Fowls of the Air : for they sow not, neither do they reap, nor gather into barns ; yet your Heavenly Father feedeth them ; are ye not much better than they ?* Could the greatest Logicians have used any stronger Arguments in the World to shew so palpably the Care and Providence of a GOD ? In case he had spoke of Tame Creatures, one might presently have answer'd, that Men who make use of 'em, provide them with Food, as in the Case of Horses, Kine, Sheep and the like. And as for the Wild ones, it might likewise be said, that they are able to fall upon what they meet with, and convert it to Food ; such as Lyons, Bears, Tygers and the rest, if he should speak of Fishes, no Body can shew that they ever suffer want in the Waters ; if of Ants or Bees, these gather their Food against the proper Season ; if of Caterpillars, Silk-Worms, and such other Insects, it may be answer'd, that in order to continue their Species, tho' their Lives are mostly limited to one Summer, their Eggs rest in the Winter, in order to produce their little Ones with the approaching Warmth, against the time that their Food is ready for them. But that for Ravens, and other Birds, that live in Desert Places,

Places, and that would otherwise perish for Hunger in a few Days, their Food should always be so seasonably provided; and that for other Defenceless, Fearful little Animals that run away from every thing, such as Sparrows and the like, their Food should be provided even at such times when they seem to be deprived of all Means of meeting with the same in the midst of a hard Winter, and when no Man himself, tho' never so Ingenious and Laborious, could instruct them how to find it (and much less meer Chance.) All this, I say, is a most manifest Proof of a great and adorable Perserver, as it is likewise of the Truth of the following Text; *Math. x. v. 29. Are not two Sparrows sold for a Farthing? and one of them shall not fall on the Ground without your Father. Or, as it is expressed in Luke xii. v. 6. not one of 'em is forgotten before God.* I leave it then to an Atheist himself, to judge, whether he can ascribe the Manner after which these little Birds, contrary to all Appearance, are kept alive every Year, with a safe Conscience, to Chance only.

SECT. XXIV. *Transition to the Fishes.*

ASK now the Beasts, and they shall teach thee; and the Fowls of the Air, and they shall tell thee; or speak to the Earth, and it shall teach thee; and the Fishes of the Sea shall declare unto thee: Who knoweth not in all these, that the hand of the Lord hath wrought this? In whose hand is the Soul of every living thing, and the breath of all Mankind. These were formerly the Emphatical Words which *Job, ch. xii. v. 7, 8, 9, 10.* made use of against those that doubt, whether there be a Wise and Powerful GOD. I do not produce 'em here to convince an Atheist whilst he has no respect for this Holy Word, but only, that these miserable Men may once again silently ex-

amine themselves, whether, what has been said before about the Birds, cannot move 'em to observe the Truth and Wisdom of those Expressions ; and if that will not entirely satisfy them, let them pass on with us to the *Contemplation* of the Fishes.

SECT. XXV. *The Miracle of Fishes living under Water ; and Convictions from thence.*

WE shall not here repeat what has been said concerning the Fishes in the *Contemplation* of WATER, nor prove more fully from thence the Goodness of the Creator, who has filled those mighty Caverns of Seas and Rivers with all Kinds of Fishes, to the end, that those vast Spaces should not remain useless ; which Fishes in some Countries serve for Bread, in others for Dainties ; and by their variety, are fitted to gratify the different Palates of Mankind. Now let one of these most Conceited Philosophers, that thinks every thing is made without Wisdom, tell us, whether he could ever have believed, if he had not known it, that there were such things as Fishes, and that any one spoke Truth to him that shou'd give him an account, that in Water, in which other Creatures can remain alive but a very short time, there was found a particular Kind of Animals that could live, move, procreate, and perform other Animal Functions : And upon seeing a Fish perform all this in the Water, whether he could help taking it for a Miracle. And, which is more, whether he could, tho' his Life were at Stake, and tho' he had consulted all the wisest Men in the World, tell how a Fish must be formed to be able to preserve itself in Water, and what would be the Difference between its Blood and other Humours, and those of Animals that live in the Air.

SECT. XXVI, XXVII, and XXVIII. *How Fishes balance themselves in and against the Water, illustrated by several Experiments.*

BUT not to dwell upon such general and well-known Reflections ; let us pass on to some Particulars ; to enumerate all would be impossible. How a Bird, only by the great Force and Motion of his Wings, does at the same time support itself, and fly forwards in the Air, has been lately shewn ; but can any one observe, without Amazement, how a Fish raises its Body up to the Surface, and again subsides to the Bottom of the Water, with hardly any visible Motion, or floats in any Part of it, without either rising or falling.

If there were in Fishes a settled and unchangeable Gravity, not much differing from that of Water, when they pass from Lighter to Heavier, that is to say, from fresh to salt Water, they would emerge, even in spite of themselves ; and on the contrary, passing from Salt to Fresh, they would subside in the same Manner just as we see, that an Egg will sink in fresh Water, and swim or float in salt Water, or a strong Pickle, as is known even to the Women. So that, to render the rising and sinking, and continuing in the same place in the Water, practicable to Fishes, without using the Force of any External Motion, it seems necessary, that according to particular Circumstances, their Gravity, with respect to an equal Bulk of Water, should be augmented and diminished ; the rather, because the several Waters in which they are found are oftentimes render'd lighter or heavier, not only by more or less Salt, but also by the mixture of other foreign Bodies.

Now let a Sceptical Philosopher ask himself, whether he can imagine, that it is without Design, that the Structure of most Fishes do compose the most wonderful and proper Hydrostatical Machines; whereby, according as they have a mind to emerge or subside, or according as the Water is lighter or heavier, they may diminish or increase their relative Gravity.

To be satisfied herein, we need only open the Bellies of a Carp, a Pike, an Eel, and many other sorts of Fishes, and we shall find therein a little Bladder, like *B D* (*Tab. XVII. Fig. 5.*) which is serviceable to 'em in all the aforesaid Purposes.

To give any one a Notion thereof, who reads this only for the first time; let him suppose a Fish *M C* (*Tab. XVII. Fig. 6.*) lying in the Water; the Bladder whereof *D B* appears in its Belly at *q*; and is so far expanded by the Air within it, that the Fish, and it together, are just as heavy as an equal Bulk of Water *E F*; by which he will know, if he understands any thing of the Principles of Hydrostaticks, that this Fish will stand still in whatever Part of the Water it is plac'd, without rising or falling, so long as it hinders either by the Muscles of its Belly, or perhaps by those of the Bladder itself, the Air within it from expanding itself farther, and rendering the Cavity of the Bladder larger.

But forasmuch as the Air that is in it continually endeavours to expand itself, the Bladder *B D* will be more dilated, and become greater, when the Muscles cease to contract it so strongly as in *b d* at *p*; and the Fish having so much more Emptiness in itself, will become lighter than an equal Quantity of Water; and therefore so long as that lasts, continually emerge or ascend, as in the Figure from *q* to *p*.

Finally, since the Air may likewise be compressed and squeez'd together; and being so on every
side,

side, will lye in a narrower Compass than before, if the Fish M C, by the contraction of the said Muscles, presses the Air inwards, and rends the Bladder b D smaller; it is plain from the Laws of Hydrostaticks, that the Fish will thereby become heavier than a like Quantity of Water, and consequently subside from *q* to *d*.

To present the Reader with a grosser Idea thereof, we need only suppose a Lad swimming, and supported by two Ox-Bladders blown up; in which case it will be easie to conceive, that if he could dilate and contract the Bladders at pleasure, when they were very small, he would sink, and on the contrary he would float when they were large; and if he could light upon a measure between both, whereby he could render the Bladders too large for sinking, and too small for floating, he would be able to stand still in any part of the Water.

A remarkable Proof that these Bladders are of the same use to Fishes, may be found in the XXIX. *Prop.* of *Borelli*, where he relates, that after having kept a Fish in a place exhausted of Air so long, till that the Air which was in its Bladder finding no Passage to go out fast enough, nor any Resistance of the external Air, did so far dilate itself, that the Bladder was burst thereby; after which they threw the said Fish into a Pond, where, during the space of a Month that it lived, it could never raise itself up with Swimming, but was always found creeping like a Snake at the bottom of the Pond.

Among my Experiments I find one, that seems to give some Light to this Matter, which was as follows; we took two Gudgeons, and put 'em into a Glass Receiver in Water, and thereupon exhausting the Air, we observed them to emerge, without being able to get downwards; after which

they swelled in such a manner, that their Eyes stood out of their Heads, but by letting in a little Air again, their Eyes sunk as suddenly ; both which Appearances happen'd every time that the Air was drawn out or admitted, without their contributing any thing thereto by their own Motion.

The reason thereof was, because the Air dilated itself in the Bladder at the same time that the external Air was exhausted from the Receiver : So that the Bladder becoming larger, the Fish was lighter than so much Water and emerged ; but the Air being let in again, and the Bladder being pressed by it, and becoming smaller, the Fish was heavier again than an equal Bulk of Water, and so sunk down.

To make the thing appear yet more visible, we took a little Hog's Bladder, in which there was very little Air, tied a little Stone to it, to make it sink in the Water under the Receiver, and we let the Bladder that was taken out of one of the Fishes, float upon the Water ; whereupon we perceived, that by one draught only of the Pump, the Fishes Bladder presently dilated itself, and the Hog's Bladder, to which the Stone was tied, ascended and floated upon the Water ; but on the contrary, by letting in the Air again, both the Bladders shrank and became smaller, and the last sunk down.

Another Experiment proved the same no less agreeably : We fill'd a little Bottle A K (*Tab. XVII. Fig. 7.*) so far with Water, that being inverted, there remained a little Air upon the Water at A ; but being put loose into a great Vessel of Water, it sunk down. But after having put this great Vessel M N Q P, under the Receiver of the Air-Pump, and drawn off the Air that pressed upon the Superficies of the Water M N, the Air that was in the little Bottle at A, missing its Resistance, did remarkably and visibly dilate itself, upon
which

which forcing the Water out of the said Bottle, it made the Bottle rise up to B ; but upon restoring the Pressure of the Air upon the Water at M N, the Bottle sunk again, because the Air at B was thereby compressed into a smaller Space, and the Water returned into the Bottle, and made it heavier again. This, if the Bottle be not too full of Water at first, may be repeated as often as you please, by every lifting up and letting down of the Sucker of the Pump.

SECT. XXIX. *The Effect of Cold and Heat, and of a greater or lesser Column of Water pressing upon Fishes, shewn Experimentally.*

BUT now in Case the Air contained in the Fishes Bladders should be always the same, and the Quantity thereof unalterable, we know that by the Gravity of the Water, and according as the Pressure thereof is greater or smaller, the said Air would be more or less compressed, as it happens likewise by Cold or Heat ; the Consequence of which would be, that the Fishes would be driven upwards or downwards oftentimes against their Will and Convenience.

To give an Instance hereof, in Case of Heat or Cold, and to shew the Proof of this Supposition, we need only let so much Water run into the aforesaid little Bottle (*Tab. XVII. Fig. 7.*) that it may sink very slowly and gradually, without much over-balancing the external Water, and remain lying at A. Then set the Vessel M N Q P, either by the Fire or in the Sun-shine, whereupon the Air at A dilating itself by the Warmth of the Water, will drive out a little Quantity of the Water that is in the Bottle, and the Bottle becoming lighter thereby, will rise up to D ; but if you let the external Water cool again, the Air will be
com-

compressed and reduced to a smaller Space in the said little Bottle, and the Water flowing into it, will sink it again down to A.

But to shew likewise, that the same Effect may be produced by a greater Depth or Column of Water; and that the Air in the Bottle may be more compressed without a greater degree of Cold, than when the Bottle is nearer to the Superficies of the Water, take the Bottle E, and by putting more or less Water into it, you may bring it to such a Weight, that when you let it go, it will float upon the Superficies of the Water M N; but by a thrust, or with the addition of never so little Water, it will sink down: Now if you take a Stick and thrust the little Bottle E down to O, you will see it continually sinking there, tho' you should raise it a little up; and again, when it is raised up to about M N, you will see it continually floating upwards, tho' you should thrust it a little down. And it may likewise be often moved in the middle this way and that way, between N and P horizontally, without either rising or sinking, if you can find the exact middle D, and holding the Bottle with the Stick against the Side of the Vessel till it be quite still, it will remain in the very place you leave it.

Those that understand Hydrostaticks, know the reason thereof, and those that do not, may learn them in *Contemplation* XXVI. Those Reasons are; that the Bottle being at O, is driven down with a Force, as F R, and upwards with another, as F S; but being at D, the Force F H, presses it downwards, and F I upwards. From hence we see, that this Bottle is every where between two Powers, pressing against each other, which are greater when at O, and both of 'em gradually less when it is at D, or yet higher: Wherefore the Air at O, suffering a greater Pressure

sure than at D, and being likewise more contracted or pressed together, the Bottle is fuller of Water, and consequently heavier at O than at D or E; it must therefore sink at O, rise at E, and at D remain in an Equilibrium, that being supposed the place where the Bottle, with the Water, and the Air it contains, taken all together, is equal in Weight to a like Bulk of Water out of it.

Now, if instead of this Bottle we suppose a Fish with its Bladder, in which so much Air is included, that in Winter the Fish, by the Expansion thereof, may emerge; and when arrived to the Superficies of the Water, may with little trouble, contract its Bladder, and the Air within it, after such a manner as to remain where he is, or to be able to sink down again: In such a Case it is plain, that a hot Summer following, this Air, the Expansion whereof was sufficient in Winter, being still the same in Quantity, will dilate itself much more strongly by the Heat, and hinder the Fish, unless he constantly exerts all his Strength, from being able to descend again.

The same Inconvenience would happen if there were less Air in the Bladder, and only so much, that the Fish might easily support itself at Top of the Water in Summer; for upon the return of Winter, or upon a Fishes descending lower, and meeting with more Cold and a greater Pressure of the Column of Water upon it, and by both these Means, the Bladder being contracted without any Concurrence on the part of the Fish, much Strength must be used to raise it up again; insomuch, that with the change of the Seasons, the Fish wou'd oftentimes have too much Air in the Summer and too little in Winter. So likewise the Fishes passing into Water of different Gravities, would be many times furnished with too
much

much or too little Air in their Bladders ; and in order to avoid all these troublesome Alterations, and to pass conveniently from one place to another, they would be obliged to remain always in a Water of about the same Weight, and as much as possible in the like Depth and Temper, as to Heat and Cold.

To prevent all these Inconveniencies, the readiest manner seems to be, that the Fishes should be endowed with the Faculty of encreasing or lessening the Air in their Bladder, according as occasion required, which likewise we see happen by the Wisdom of the Creator ; forasmuch as their Bladders have a Communication with their Stomach by the Means of a very small and narrow Tube ; so that they can diminish the Air by discharging from the Bladder thro' the Mouth, and increase it by drawing it in again ; about which *Borellus, Prop. CXI. Part. I.* has this Observation ; That the Bladder is empty when the Fish being *in Vacuo*, discharges a great many Air-bubbles by its Mouth ; and the swallowing in of Air may perhaps be the reason, why we often see the Fishes moving their Mouths in the upper Part of the Water near the Air.

SECT. XXX. *Convictions from the foregoing Observations.*

Now if a deplorable Atheist has taken the Pains to read this, and understands it, let him tell us, whether it can any ways seem probable to him, that so many Laws of the Water, of the Air, and of the Motion of the Muscles in Fishes are so accurately observed by meer Chance ? or could blind Nature, ignorant in itself of all its Effects, produce such a Difference, as on the one hand to furnish the Fishes with such a Bladder, and Birds on the
other

hand, tho' they likewise move in a fluid Matter, or in the Air, with quite a different Method of Progression, since such a Bladder by which a Bird were to be raised up, must be lighter than the Air, and for that reason empty of it. Now they who ever proposed to raise a heavy Body in the Air, with a Globe out of which the Air is exhausted, know first, That the Circumference thereof must be made of a heavy Matter, least, being thin, it should be unable to resist the Pressure of the external Air upon any Accident ; and besides, tho' all this were not observed, yet it must be of so disproportionate a Magnitude, that no Bird, being incumber'd with it, could be able to fly : Not to take notice, that the Greatness of a hollow Brass Globe (that being empty of Air without lifting up any heavy Body, it might ascend alone, and of itself) is computed by Mr. *Leibnitz*, in the Philosophical Transactions of *Berlin*, published in the Year 1710, p. 127. to be such, that the half Diameter thereof, would require to be above Twenty thousand times longer than the Thickness of the Metal of which the Crust of the said Globe must be composed ; so that the said Globe being an Inch thick (tho' that perhaps would not be sufficient to resist the Pressure of the external Air) the whole Magnitude of this hollow Globe would take up some thousands of Feet. I have expatiated here something the more, to convince Sceptical Philosophers, that are any ways versed in Modern Experiments, that the Structure of Fishes is entirely opposite to what is proper for the flying of Birds ; and that it is undeniable, that in order to make Fish and Birds move upwards and downwards, (each of 'em in their different Fluids) different Means must necessarily be applyed ; which being performed in both with so much aptitude to all these Circumstances,

I leave

I leave it again to their own Judgment, whether this does not plainly shew the Wisdom and the good Pleasure of a Great Creator.

SECT. XXXI. *Fish Swim with their Tails.*

Now, if we observe farther in so many Fishes, that in order to their Progressive Motion in Water by Swimming, they do not make use of their Fins as Oars to row with, nor after the same manner as the Birds do their Wings in the Air, but by the help of their Tails, much after the same manner as a Boat moves when they put an Oar out at the Stern and paddle with it backwards and forwards.

Is there no Wisdom to be discover'd in this (since Fishes stand in need of no external Motions for raising and sinking their Bodies, as we have shewn before) that their Instruments are so formed, that no time should be lost in their advancing forwards? and that having made a Motion with their Tail, by which they are protruded, they have no occasion to draw it back again, in order to dispose the same, to repeat the said Protrusive Motion: This the Birds are forced to do with their Wings, that they may strike upon the Air every time perpendicularly, in order to support themselves therein; but the Fishes by putting their Tail in its former Place and Disposition, exert the same Force on the other side, which contributes as much to their Progression, as the first Stroke had done? Is it now by Chance, that these Tails, like the paddling Oars, are broad at Bottom, that they may act with greater Force upon the Water; and that they are composed of a strong Membranous Matter, which is however flexible; that the Muscles of the Back are of such a Structure, as to move the Tail with a sufficient Strength;

even

even so far, that the Violence which the larger kind of Fishes, such as Whales exert therewith, is so terrible, that one can hardly read the Accounts thereof without being amaz'd?

SECT. XXXII. *The Use of the Fins.*

BUT forasmuch as in all Bodies that float in Water, the heaviest Part always tends downwards according to the Laws of Hydrostaticks, Would it not likewise follow from hence, that since the Backs of Fishes, quite contrary to those of Birds, are the heaviest Part of their Body, they must always turn their Bellies upwards in the Water, as it is commonly observed to happen in dead and floating Fish, since their Bladder cannot be then compressed, but the Air being dilated therein, makes the Fish float and turn its Belly upwards, the Back being not only heavier, but the Belly also lighter by such Expansion of the Bladder than when the Fishes were alive.

Can it then be imagined that the Wisdom of the Creator did not foresee this in the Forming of Fishes, to which he has given two Fins under their Belly, by which they support themselves upon the Water, and by giving them the Faculty of Swimming whilst alive with their Bellies downwards! of which we may find an accurate Examination in *Prop. CXIII. of Borelli*, who having cut off all the Fins under the Belly of a Fish, and in that Condition thrown it into the Water again, found it continually staggering on one side or t'other, without being able to support itself in the natural and common Position of Fishes.

But besides this, to the end that the Fishes might be provided of every thing that is necessary for them towards Swimming, it seemed to be still wanting, that they should be able conveniently

ly

ly to stop that Progress which they had acquired by their Tails, and to be able to turn to the Right or to the Left in their Course, neither of which could be done by the Tail but with great Trouble. For this Purpose we find the Fishes provided with two Fins on the Sides, by which, when they extend 'em both together against the Water, their Motion may be stop't; and if they stretch out one and keep the other close, they may turn to that side whence the Fin is displayed; just as we see happen in a Boat which turns to that side where one Oar is thrust out in the Water to stop its Progress.

SECT. XXXIII. *Creatures that live in the Air
see confusedly in the Water.*

IN Case this does not yet suffice to convince a Sceptick that there is a GOD proposing to himself a wise End in all his Designs; let him reflect upon what follows, which seems to be capable of removing all farther Uncertainty.

It is known to every one that ever duck'd under Water with his Eyes open, that one may indeed see the Light and many Colours of Objects, but that all will appear Confused and without Distinction. Now we have shewn before in *Tab. XI. Fig. 2.* that the Rays of Light *BC*, and *BC* coming from a Point *B* into the Air, continually diverging or spreading wider and wider from each other, meet in the Eye with a watry Humour, thro' which they do not then proceed directly from *C*, according to *gg*, but are refracted towards each other at *CD*, which refraction or bending being repeated again the second and third time at *D* and *E*, they both of 'em unite again at the Bottom of the Eye at *b*; in which manner of collecting all the Rays proceeding

ceeding from B into this one Point *b*, all the Exactness of a good Sight consists.

Let us now suppose this Eye, as also the Point B, in the Water; then the Rays BC and B C, will come out of the Water upon the Aqueous Humour CC. And since, in order to be bent or refracted, they must likewise change the Medium thro' which they pass, these Rays therefore remaining in the said Medium or Water, and passing to C, will not be broken or bent to DD; but proceed directly to *g g*, till they meet the Crystalline Humour ST. So that altho' they be refracted after the usual Manner, thro' the same at D and E; yet failing of the first Refraction at C, they will not be able to approach near enough to each other, in order to be collected just at one and the same Point *b*, which is at the Bottom of the Eye: But this Point of their Collection will fall farther behind the Eye, for Instance, at *k*; for which reason every Point, as B, with its Rays, will fill the whole Space *mn* at the Bottom of the Eye; which happening in like manner from the other Points of the Object near B, the Rays of these several Points will be mingled together at the Bottom of the Eye, even in the same Space between *m* and *n*, and so occasion an entirely distracted or confused Sight, because each Point B is not seen in a particular Point *b*; after the same manner as in a dark Chamber, when you hold the Paper a little too near to the Glass, the Objects painted upon it are all confused, whereas by holding it at a due Distance, it represents the most accurate Painting that Eye ever beheld.

SECT. XXXIV. *To prevent this confused Sight,
Fishes are endowed with rounder Eyes.*

NOW this is the Inconveniency that would happen, and be peculiar to all Fishes, if their Eyes were of the same Figure with those of such Creatures as live in the Air. Now in Case any one that should doubt of the Wisdom of GOD in the Formation of Fishes, does understand the Laws of Opticks; and if he were to tell us how this Inconvenience in Fishes might be prevented, and how they could be furnished with a distinct Sight; such his Skill in Opticks might indeed teach him some of the Methods whereby the same might be brought about; as for Instance, by holding a round Glass before the Fishes Eyes, as old People do, who find the same defect in their Eyes, because they become less round and more flat by Age; but it is plain, that such a thing can't be done for the Fishes. The making their Eyes longer, so that they might be extended not to *b* but to *k*, would indeed render their Sight more distinct; but then it would bring along with it this Inconvenience, that their Eyes, by losing so much of their Roundness, could not easily be turned to all Sides. And, to pass over others, let him tell us, whether he could have thought of a shorter Way, than by making the Crystalline Humour of the Fishes *ST* rounder, and of a smaller Circumference than the Eyes of those Creatures that live in the Air; and he will know, that according to the Rules of Opticks, this will be sufficient to make good the Defect, and cause the Rays to fall so much closer upon the Crystalline Humour.

Now this is what we really find in Fishes; in which the said Humours are sufficiently Convex, and like little Globules, as may be daily observ'd

in the Eyes of boiled little Fishes ; and as appears even in the Eyes of great Whales, which are very small and round, and which if they were larger, and consequently of a flatter Circumference, would take up a great Part of their Heads for the use of their Sight.

SECT. XXXV, and XXXVI. *The Fruitfulness or Numbers of Fishes.*

THAT we may be more confirmed in the Acknowledgment of a GOD, we need only contemplate the Multiplication and Fecundity of Fishes, which happens in many Kinds of them after so wonderful a Manner, as has been shewn already upon another occasion ; some of the Females discharge their Spawn and the Males their Melt or Seed in the Water near each other, and without any farther Acting of the Fishes on either side ; both these Seminal Matters being intrusted to the Water, do produce Young Fishes of the same Kind.

Now can any Body imagine, that this Spawn and Melt of the Males and Females, together with the Water, have the Property of Engendering Fishes after such a manner by meer Chance, and without a wise Design ! The rather, since we see that herein is a Direction or Disposition of propagating the Species of Fishes above all other Creatures in an infinite Number ; for if there were not some other extrinsical Impediment, every single Grain or little Egg that we find in the Spawn, would become a Fish. So that it is no wonder what some Travellers relate concerning their Fruitfulness ; as for Instance, that in the Island called *John Fernandez*, in the *South-Sea*, there is such a vast Quantity of Fishes, that one Man can in one Day catch enough to feed 200 Persons.

I have often thought of the Text in *Genesis*. i. 20. *And God said, let the Waters bring forth ABUNDANTLY the moving Creature that hath Life*; whereby the two aforesaid particular Properties, concerning the great Encrease of Fishes are, as one may say, pointed out with the Finger; the rather, because in the 21 Verse it is repeated with the same strong Emphasis, *which the Waters brought forth ABUNDANTLY after their Kind*.

Now that this has respect to Water, which as a second Cause, produces these Fishes out of their Spawn, seems to be deducible from hence, That the Procreation of Birds being mention'd in the said Verses, is not ascribed to the Air, tho' they live and are produced therein, as Fishes in the Water; as also, forasmuch as afterwards mention is made in the 24th Verse of the Earth (of which all Creatures do at present consist, since all of 'em receive their Food from thence) after a different Manner. And moreover how much this first Command of the Creator does continue firm and prevail even to this very time, appears especially from hence, that in both the quoted Places the Expression of *bringing forth abundantly*, is only found in relation to Fishes, but not at all mention'd concerning Birds and Beasts, tho' they are compared with one another in this same Chapter. Now that the Fishes do multiply in much greater abundance beyond other Creatures, even to this day (tho' an abundant Production is likewise ascribed to other Places where there is no Comparison; and in *Genesis* the viii. and 17. and the ix. and 7. the same radical Word is used) at least, that they can be more multiplied, is obvious enough, from the prodigious Quantity of Eggs in their Spawn, and from other Relations that have been hinted at above. Thus in *Pf.* civ. they are said to be *innumerable*; and upon the same Foundation *Jacob* wishes that

Ephraim and Manasses may grow into a Multitude (or, as it is in the Margin of that Text, *as Fishes do encrease*, Gen. xlviii. v. 16.) At least, it is plain from hence, that those Words were not spoken without a Fundamental Knowledge of the Properties of Fishes, as two great Circumstances in which they differ from other Creatures, namely, that the Effect of Water in their Production, and their great Fecundity.

SECT. XXXVII. *The Curse appears from the Production of Fishes.*

THERE may still one Remark be made about the foregoing Matters ; namely, that this so great Multiplication of the Fishes, which seems to be the necessary Consequence of the Quantity of their Eggs, is not however observed to be so at this time. Now such as allow the above mention'd Text to be the Word of God, may discover herein the Force of the Curse, which after the Fall of Man is extended to all things ; for the sake of which not only the Trees are less Fruitful than from their Contexture one might have expected them to be (of which hereafter more largely) but Men likewise live a smaller Space of time than their Structure seems to promise (of which something has been said above in *Contemplation XII*) Now if this be seriously consider'd by a Sceptical Atheist, it will not be easy for him to assign any other Cause besides this Curse for the same, nor to remove the Difficulty which offers itself, that so many things, and among them the Fishes, do not answer the Expectation which we might justly entertain from their Structure ; and which is more, have not in so many Ages answer'd the same, tho' every thing be compleatly disposed thereto.

SECT. XXXVIII. *Creeping Creatures not yet
thoroughly known.*

Now how the Creeping Creatures, such as Worms, Snails, &c. do move from one place to another without Legs, and other external Instruments, has not (that I know of) been yet examined into with so much Accuracy as to enable any one to say any thing satisfactory about it ; he that desires any account thereof, and how, according to the Opinion of the great Mathematicians, such Motion may be perform'd, let him consult *Borelli* in his Book about the Motion of Animals, *Part II. Prop. XIII.* Mr. *de la Hire*, in his Treatise of Mechanicks, §. CXII. p. 358. seems to have carried his Observations upon this Matter somewhat farther, affirming, that in great Worms, such as are found in the Sea, the Muscles can be discover'd, some of which encompass the Worms like so many Rings, others are extended lengthwise in the said Worms. Now if this latter sort be so form'd as Mr. *Borelli* describes them, the Serpentine Motion of Worms seems to be performed by those Muscles; since when the long Muscles are contracted, the Worms becomes shorter, and when the round ones, it is stretched out in length. But forasmuch as the Structure itself of these Creatures does not seem to have been sufficiently enquired into, we shall be silent about it, that we may (as much as possible) avoid substituting Conjectures, tho' of very learned Men, and proposing them to any one, instead of the true Works of the Creator. This only would I ask of any one that does not own a God, whether it can appear reasonable to him to suppose, that a Worm is made without Wisdom, when so many learned Gentlemen, tho' urged

urged to give an account thereof, must acknowledge it to be a very difficult Question.

SECT. XXXIX. *Insects, Silk-Worms, Caterpillers, &c.*

NOW if we pass on to the Examination of the surprising Structure of so many different Kinds of Shell-Fish, both great and small, and yet farther of Caterpillers and Worms, and of the Aurelias proceeding from them, and of Flies, Grasshoppers, Beetles and the like; of which at present the Closet of Persons of Distinction (that delight themselves in contemplating the surprising Works of the great Creator) do with laudable Charge and Pains abound; and wherewith a great many Books besides are filled, without near comprising all the kinds thereof; to produce many Instances thereof will not be necessary here, since they are to be found in so great a number elsewhere.

But to instance in two or three of 'em; ask any Body, be it who it will, whether he can think, that it is by meer Chance, that a Silk-worm comes out of an Egg furnished with all the Instruments for Moving, Eating and Digesting its Food as other Animals are: That afterwards Spinning itself up with the Silk that comes out of its own Bowels, it is turned into an Aurelia, from whence at last proceeds a Butterflie, which after Copulation with a Male of the like kind, lays Eggs again, which in the following Year become Silk-worms; this is known even to our Children that are wont to breed the same.

They that in Summer meet with so beautiful a Butterfly as is represented, *Tab. XVII. Fig. 8.* flying with Wings, running with Legs, and furnished with all the necessary Parts for Nourishment and Generation; when they read in the Observations of

the accurate Mr. *Goedart*, that the said Creature was a Caterpillar B before, and that it was first turned into the Aurelia C, and afterwards became a Butterfly; could they, seeing such Metamorphoses, and change of Figures in so many kinds of Animals as are briefly named above, and of which the said Author faithfully reckons up a great number; could they look upon 'em, I say, otherwise than as so many Wonders of a great and wise Creator? Or can they perswade themselves, that all this is brought about by Causes divested of Understanding and Knowledge? And the rather, forasmuch as the little Eggs of those that we know are found by Experience not sooner to disclose their Young ones, than till the Herbs and Leaves that are to serve them for Nourishment, do spring out of the Ground or Trees. Now if this be true, as several Naturalists pretend they have observ'd, let an Atheist see whether he can calmly persist in that Opinion, that here is no room for an End and Design of a great Preserver. And if the same has place here, and that there is undoubtedly so great, so adoreably Wise and Powerful GOD that governs all Things; woe be to them, yea, double woe to all that deny him.

SECT. XL. *The Consideration of small Animals in general.*

TO return to the Matter again; Since these Insects together with Shell-Fish, have been consider'd with great Diligence by many learned Men, every one may find Matter of Astonishment in what has been transmitted to the learned World concerning the same; and I hope that this happy beginning, which Men of Note and Judgment have made, may in process of time be an inducement to great Minds,

Minds, to contemplate these small *Animals* in certain other Views, and to enquire farther into the Wisdom and Art that do so manifestly appear in the Instruments which they use for Motion, Nourishment, and all external Sensation ; by which particularly the Glory of their great Creator (which does not appear less in the Structure of a Fly, a Flea, or a Mite, than in the making of the biggest Elephant) may be demonstrated by yet stronger Arguments against those that refuse to acknowledge the same.

He that doubts hereof, let him consult those great Enquirers, who by the help of their Microscopes have discover'd as it were a new World, and thousands of otherwise invisible Creatures ; in the unconceivable smallness of which, not only the Desires of a curious Eye will meet with intire Satisfaction ; but likewise the manifest Designs of the Creator and his Wisdom and Goodness, (even with respect to these *Animalcula*, that by reason of their Smallness are almost invisible) will shine forth as clear as the Sun.

SECT. XLI. *The Eyes of a Beetle, and Con-
victions from thence.*

FORASMUCH as whole Books have been writ upon this Subject, I shall only give an instance in the surprising Structure of the Eyes of a *Beetle*, the like of which we also find in Flies. The great Creator, in the Formation of this Insect, thought fit to make the Eyes thereof immoveable, which in bigger Creatures can be turned to all Sides ; shewing thereby that he does every thing according to his good Pleasure, and will be bound to no Laws. Now it is certain, that these Beetles and Flies, not being able to turn their Eyes, can only see that Way towards which the opening of
their

their Eye is directed ; but because the bountiful Preserver of all things does likewise extend his Goodness even to these most contemptible Creatures, and that they may be aware both of the Birds, and other Persecutors that prey upon 'em, and use them for Food ; and that they may spy them not only before, but sidewise, and likewise behind, in order to their Preservation, he has been pleased to cause their Eyes to stand out of their Heads, with a Protuberance or Convexity, and bestowed upon 'em such a Figure in a manner as we find in Glasses, which being ground with many and different Faces, do multiply the Object as many times as there are Superficies upon the Glass : So that each of these little Planes or Superficies of the Eye do appear thro' a good Microscope to be an exact Hexangular Figure, as we may see in a Beetle's Eye (*Tab. XVIII. Fig. 2.*) ABCD, and in that of a Fly (*Fig. 3.*) GEF. They that look upon it in this Table, must be pleased to take notice, that it is represented here much greater than it really is, and so as it appear'd through a good Microscope ; whereas otherwise each of 'em are so small, that the Observer, Mr. *Leuwenhoek*, having counted those that are in the middle Line of the Eye, justly concludes, that the number contained in the Superficies thereof does amount at least to 8000.

From this Structure every one may infer, that these Insects by the means of so many different and convex Superficies, are able to see upwards, downwards, sidewise, before and behind, as if they had so many Eyes, with as much Ease, and perhaps more, than any other Creature that can turn one and the same Eye every way.

One that is well versed in Dioptricks, and understands the Nature of Vision, might perhaps find this Defect in such a Structure ; that in case these

these Insects must see like others, it would not be possible if the Superficies were flat (as in the polished Glass or Diamonds, to which they were compared) that the Rays passing thro' them from a Point, could be collected in a Point at the Bottom of the Eye, which, as we have shewn above, is required to a distinct Sight, and which is besides, the reason why the Eyes of Fishes must be rounder than those of other Creatures living in the Air. So that these Insects, according to the Laws of Vision, might indeed have a confused Sensation of Objects without them, but yet see nothing distinctly thereof, unless each of the said little Superficies were in themselves Convex. But can any one who justly objects this Difficulty, observe again upon farther Enquiry, without being amazed at the Wisdom of the great Creator, that each of these exceeding small Superficies are of a Convex and Globular Figure, to the end, that they may serve for a distinct Sight to each of these little *Animals*, according to the exact Rules of Opticks, as those that examine them more nicely and attentively will find. But forasmuch as the globular Figure cannot be compleatly shewn by the said Microscopes, let any one take the Eye of one of these little Creatures, and observe them nicely against the Light of a Candle, holding them at a little Distance from the Glass, and he will then discover as many Images of the Flame of a Candle inverted, as there are Superficies in the Eye of a Fly, all encompassing the middle Superficies upon which he looks as in a Right Line: Which burning Candles are so exactly delineated, tho' all exceeding small, that as the Flame of the Candle itself moves upwards, the Picture of it will appear to do the same every time, but inverted; just after that manner, as one may see thro' a round polished Glass, the Picture of a remote Candle in-

inverted upon a white Paper; or otherwise looking thro' a Magnifying Tube of two Glasses; as likewise by keeping ones Eye behind the Focus of a round Glass; in all which Cases one sees the Object turned upside down.

Now every Mathematician that is never so little versed in Opticks, knows that this cannot be done by a concave or flat Figure; and that, in order to shew the exact Image of a luminous Object inverted (which is here beyond Expectation every way distinct) a convex or a more protuberant Figure is only required; which cannot be doubted by any one that understands the Refractions of Light.

I must confess, that for my own Part, I could not oftentimes see and observe without Emotion, a Providence operating with the wisest Views even the very smallest Things, and appearing not only so visibly, but so adoreably too in these small *Animals*. And since such a Figure would create trouble enough to the most skillful Glass-Grinder, if he were to form a great and manageable Glass like it, how impossible would it be for any humane Art to extend itself so far as to communicate such a Shape, and all the Properties belonging to Sight, to an almost invisible *Animalculum*. Now if these little Particles or Eyes were not transparent, there would be no Sight; if each of 'em were not round, there would be a Sight but confused; if they were not disposed in a convex Superficies, these Insects would not be able to see round about 'em, because of the Immobility of their Eyes; if the Membranes thereof were not supplied with Humours proper for them, and such as must be conveyed thither by unconceivably little Vessels, the Sight would be ruined by Dryness, as Experience teaches us when Eyes continue too long dry: Now all this is required, and
all

all this is found in each of these Insects, and every one of these Circumstances is wonderful : Can we then see them all concurring in so small a Compass, and coolly affirm, that it is all by Chance ?

Now every one that has seen the curious Structure of the Eyes of these so small *Animals*, in the Observations of Mr. *Lewwenhoek*, or other Naturalists, or made the Experiment himself, may imagine, how overflowing the Wisdom of the Great Creator thereof is, who has vouchsafed to display so much Skill and Contrivance to render Happy so many thousand Millions of such contemptible Insects (how much more then a rational Man) and to cause them to see distinctly.

SECT. XLII. *Something concerning the beginning of Action in Beasts.*

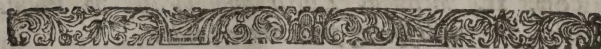
MY Reader must not be surpris'd, that in this *Contemplation* of Animals, I have said nothing of the Principle of the Actions in Beasts ; concerning which Philosophers differ so much among themselves, some of whom look upon Beasts to be no more then Clock-work, without either Sense or Understanding ; but others think that another Principle of their Actions must be allowed to enable Beasts to Act as we see 'em.

The chief Reasons that have induced me to pass over this Matter in silence are, that both these Parties agree in owning a G O D, how much soever they differ in other Sentiments ; wherefore, since we only write here for the Conviction of Atheists, we thought it unnecessary to engage ourselves in this Subject.

However, to say one Word about it to unhappy Infidels, how much soever we see perform'd by Beasts, that may appear surprising to us, and how much soever they may seem to mimick the Actions
of

of Men ; this is certain, that we could never yet discover any thing in them that was like any Sign or Character of the Knowledge of a G O D, or of his Service. Let then an Atheist learn from hence, that far from deserving the Title of a *Strong Mind*, upon account of his deplorable Philosophy, the only Reward that he is like to receive for the Pains he takes therein (I say it with Compassion for his Blindness, and without Design of the least sarcastical Reflection) is, that it serves to distinguish him from a rational Creature, and in this Case sinks him down into the Condition of a Beast, and yet without giving him this comfortable Assurance, that he is to expect nothing else after his Death, but to be reduced to the State and Condition of Irrational Beings. And I leave him to judge for himself, (since there appears in Men the Knowledge of a G O D, but by no means in Beasts) whether the Opinion of Christians are so absurd, when they maintain, that Death does entirely annihilate Beasts, but that the Souls of Men do still remain ; forasmuch as the Knowledge of an eternal G O D does exert itself so much more adoreably in a Being that is framed for Eternity, and so adapted to glorifie that G O D for ever.

CON-



CONTEMPLATION XXIII.

Of PLANTS.

SECT. I. *Transition to PLANTS in general.*

NOW for the farther Confirmation of what we aim at in all these things, let us pass on to the Plants, and tho' a great many of them be still unknown, yet, what the Experiments of Enquirers have discover'd thereof of late Years, is sufficient to prove, that a wonderful Power and Wisdom does appear in adapting them all to their respective Uses.

Now if we should take notice of nothing more, than what is already sufficiently known both to the Learned and Unlearned, namely, that we see a little Seed first taking Root downwards in the Earth, and then shooting up a Trunk or Body in the Air, and in some producing Branches, and in others Leaves, Flowers, and Fruit, in which again there is Seed, by this means multiplying the Plant, which when Dead, revives again in the Posterity of the same Species; let every one consider with himself, whether he could expect such a constant Circulation and Series of Plants in Seeds, and again of Seeds in Plants, that has lasted so many Ages without any Variation; and all the Instruments necessary thereto, from mere Chance, and a confused concourse of Atoms.

SECT.

SECT. II. *Without Earth and Water no Plants will spring from their Seeds.*

LET an Infidel or Sceptick examine farther the Earth and the Rain-Water (of which when we treated about Water itself, we shewed that all Plants do mostly consist) after as many different Ways as he can possibly ; and then let him see, whether he can with any reason prove from thence how it comes to pass, that when we sow the Seed of a fine and sweet smelling Flower, or of nourishing Corn, and another of a poisonous Plant in the same sort of Earth, each of 'em will produce a Plant according to its own Nature, differing so much in Figure, in Strength, and other Properties; and let him say, whether it does appear to him with any kind of probability, that all this is done without Wisdom ; and the rather, forasmuch as Earth and Water being excepted, Experience has shewn in so many Cases, as the Learned *Malpighi* observes, *de Sem. Veget. p. 12.* that neither Urine nor Lye, nor Spirit of Copperas, nor Chalk, nor Salt-petre, if in too great abundance, nor Antimony, nor burnt Hartshorn, nor many other things when mingled with Water, and the Seed soaked in such Water, or when water'd with the same after they spring up, can produce any encrease or growth thereof. Nor according to the Observations of the said Author, can Seeds produce their usual Plants in simple Water only ; they that would be fuller informed of this Matter, may consult that accurate Writer in the Place above quoted.

Now when so Understanding and Learned an Enquirer has made so many Experiments about Plants in vain ; and consequently, since 'tis not so easy for any one to discover wherein consist those Properties that are requisite for producing Plants out of their Seeds, and yet we see, that they are
in

TAB. XVI

Fig. 7

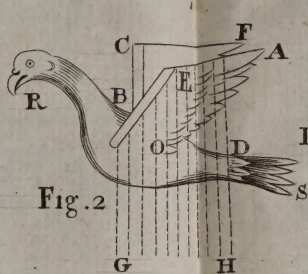
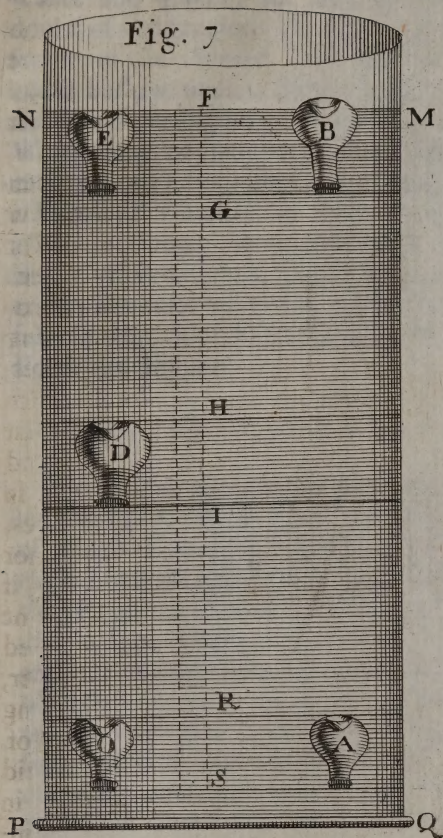


Fig. 2

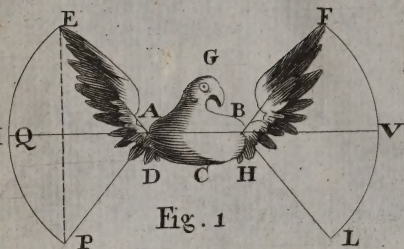


Fig. 1



Fig. 3

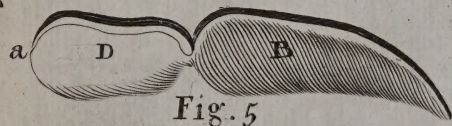


Fig. 5

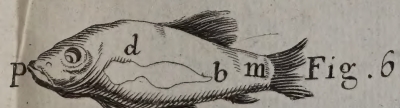


Fig. 6

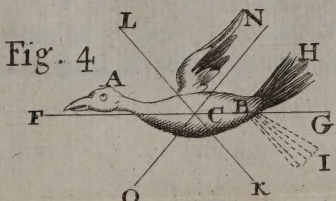


Fig. 4

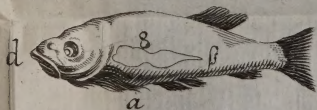
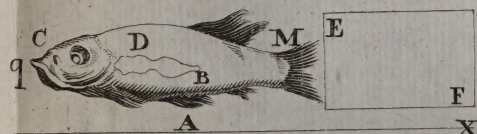
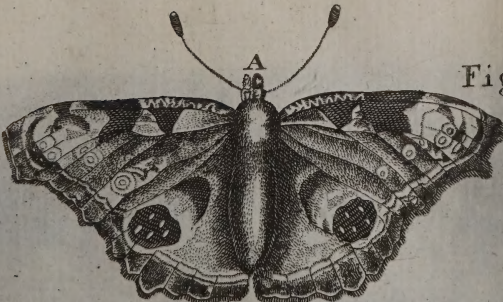
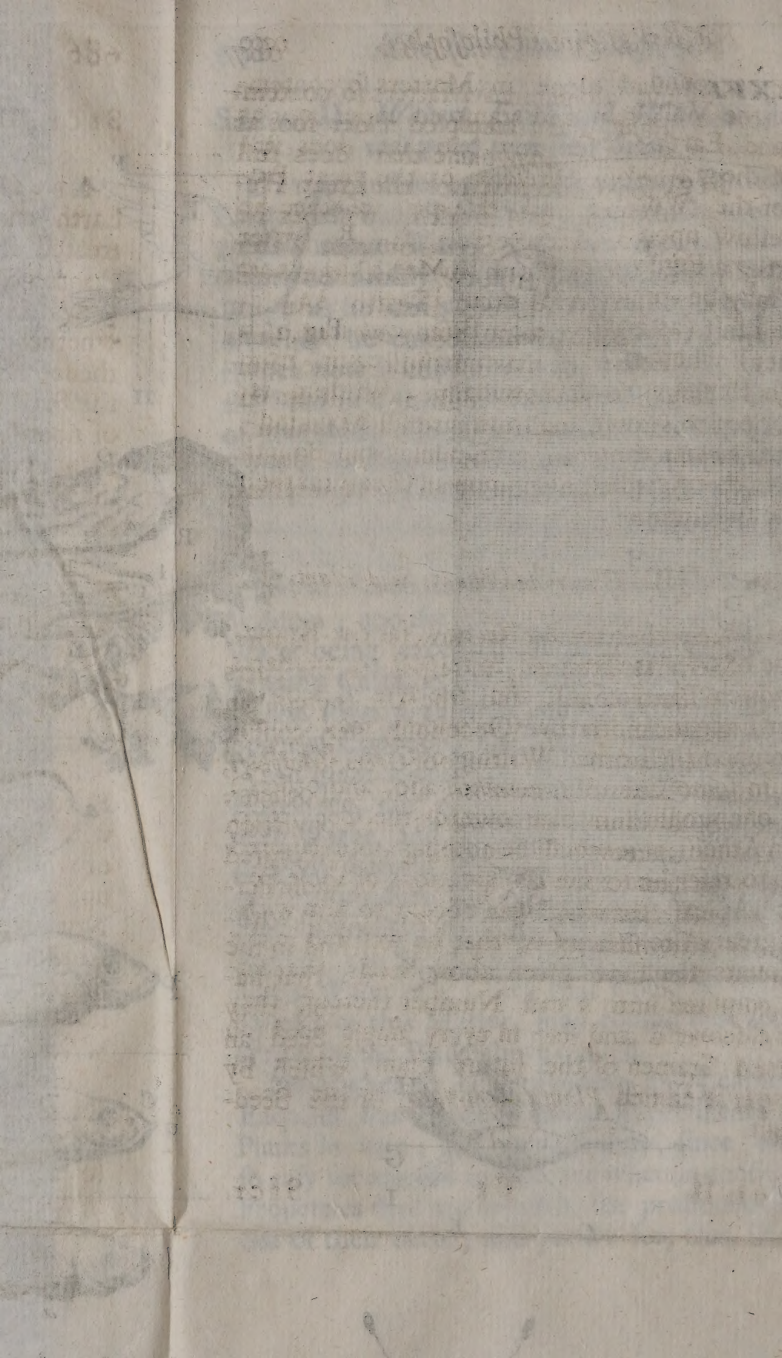


Fig. 8





in a manner found alone in Matters so contemptible to the Vulgar, and trampled under foot as Water and Earth; let any one that does still doubt of the gracious Direction of the great Preserver of the World, ask himself, whether he could bestow upon a simple Seed, or upon Water and Earth, a Figure or Form, by which the whole World may be preserv'd from Death: And in case he can't (as hitherto no Body ever had such a Faculty) whether he has not just cause, from all these things, to acknowledge a Wisdom far Superior to his own, and to that of all Mankind; and at the same time too, a Goodness and Bountifulness that has bestow'd upon all Creatures their Food and Support.

SECT. III. *Every Seed has its Seed-Plant.*

NOW they that would see how far the Knowledge of Men has attained, in respect to the Parts of which Plants consist, and the Use thereof in their Encrease and farther Oeconomy, may consult thereupon the Learned Writings of *Grew*, *Malpighi*, and in some Cases of *Leurwenhoek* also, and others; and one would think that towards the Conviction of an Atheist, there would be nothing more required than to refer him to the Observations of those Persons: At least, that which can't occur to him without great Astonishment is, that he will find in the Accounts they have given about Seeds, that having enquir'd into a vast Number thereof, they have discover'd and seen in every single Seed an involved Stamen of the future Plant, which by *Malpighi* is named *Planta Seminalis*, or the Seed-Plant.

SECT. IV. *The Seed-Root and Pluma in a Bean.*

TO say something thereof, which every one may easily try; take some great dry Beans, and steep 'em 24 Hours in Water, than take them out and lay 'em in a place that is dry but not cold, so long till, as the Gardeners term it, they begin to shoot out; strip the Skin off of one of 'em, and you will find the Body of the Bean consist of two Parts, lying with their Planes against each other, and having a little white Stalk or Sprig by which they are joined together; for Instance *Tab. XVIII. Fig. 4. a a a*, and *a a a* are the two Parts of the slit Bean; *d c* is the white Root-Sprig fasten'd to both the sides, and which afterwards in the Earth becomes the Root of the Plant. Now let an unhappy Sceptick say, since this Root *d o*, must first grow and spring out before it can be nourished by the Earth and be turned to a Root for the whole Plant, whether he can imagine that it comes to pass without any proposed Design, that in the Body of the Bean, and in both the Parts thereof, there is another Root placed, represented here by *b b b b*; which is carried on to the white little Point *c*, on each side with a Branch *d d*, and thereby furnishes this little Root-Sprig *d c*, *d c*, with nutritious Juices, in order to communicate there-to the beginning of its Encrease, and the Power of becoming a Root before it be able to draw any Nourishment out of the Earth.

From this little sprouting Root *d o*, there proceeds to the other side another little Body *e*, which being the Trunk or Stalk in Miniature does consist of a very little Stalk and Leaves, upon which account it is called by Dr. Grew, the little *Pluma* or Feather; and the said Sprout of the Root *d c*, and this little Feather

Feather *e*, do make together the Stamen of the following Plant.

SECT. V. *Each Plant has two Roots.*

So that almost every Plant (as Experience teaches us, that the same thing happens in almost all the known Seeds after the same manner) is thus furnish'd with two Roots; the first of which is that describ'd here by *bb* and *bb*, and which spreads itself thro' the Body of the Seed, being therefore call'd the *Seed-root* feeding the little Root-Sprout *dc*, and the Pluma *e*, so long till the first of those is big enough to draw Nourishment to itself out of the Earth, and then it becomes the second and last Root, causing the Pluma, now become a larger Trunk, to grow up to a compleat Plant. From whence it is farther apparent, that the Matter of the Seed itself, or of the Bean by which the first Seed-Root *bbbb*, is extended, performs almost the same therein (by making the Root-Sprout *dc*, put forth at first) as the Earth does afterwards when it becomes a larger Earth-Root; that is, does feed and increase the whole Plant.

This Seed-Root *bb*, *bb*, appears more plainly in large Beans, and in the Seeds of Lupins, than in many others, according to the Observation of the said Dr. Grew. And in case one cuts a fresh cropt Bean into thin Slices crosswise, one may see in every such Slice the course of the little Seed-Roots (represented here by little Points or Dots) quite to the end; (see *Tab. XVIII. Fig. 5.*) where *bb* shew the Dots through which the Seed-Root is cut across; and if you should cut off thin Skins lengthwise from the said Bean, you may see the little Branches of the said Root that were just before cut across. *Tab. XVIII. Fig. 6.* shews the

said white Lupin, as it appeared to Dr. Grew, of which *c* is the *Pluma*, *b* the Root, *d d* the Pith, and *aa* the Branches of the Seed-Root. *Fig. 7.* is the Seed of a *Gourd*, where the said Gentleman says, that one need only split it in two in order to see within it the said Seed-Roots clearly and accurately in all their Branches. In other Seeds, where these Roots are not quite so visible, either because they are of the same Colour with the rest of the Body, or for other Reasons, yet the Root-Sprout, or the Feathers, may be always seen plain enough. [*Vide Grew, Cap. I. of his Anatomy of Plants.*]

SECT. VI. *The Cavity in the Bean for the Pluma.*

ONE might here add other Particulars; As for Instance, that in *Fig. 4.* the little *Pluma e*, is the Origin of the future Trunk, or rather the Trunk itself in miniature; for which reason those that know how very necessary it is to the Existence of the Plant, and who likewise observe the Tenderness thereof, must they not be convinced, that it was with some View and Design, that in each Part of the Bean, there was form'd a small Cavity to place the said *Pluma*, and to preserve it from all Inconveniencies, in such a manner, that the Beans may be handled, thrown together in Heaps, and tossed into Sacks, without the least prejudice to the said tender Trunk?

SECT. VII. *The Hole in the Skin of the Root-Sprout.*

BESIDES all this, we see in the great Seeds, such as Beans, even with the naked Eye (and in those that are smaller, with the Microscope) that the external Coat or surrounding Membrane is always pierced or bored through with a very little Hole, directly opposite to the Point of the Root-Sprout *e*; to the end, that when the Seed is sown, and begins to shoot forth, this Root-Sprout may not be hinder'd by the Thickness of the closed Bark or Skin, from growing out and spreading itself in the Earth; in order, as we have said before, to serve afterwards for an Earth-Root to the Plant. Insomuch, that even Nuts, and hard Peach-stones, have the like Orifice or Hole to make room for the putting forth of the said Root-Sprout.

SECT. VIII. *The Nutricious Juice or Sap changes its way in the Seed.*

THOSE that desire to be informed of other Particulars, in which the Wisdom of the Creator does appear, may consult the aforesaid laudable Authors, concerning the Structure of the Seed itself, and learn thereby to acknowledge a higher Direction of Him that has adapted the Instruments of the Seed thereto; among which there is one that cannot be contemplated without Wonder, namely, that the Nutricious Juice, which proceeding first from the Matter of the Body of the Seed *a a a a*, Fig. 4. through the Seed-root *b d*, causes the Root-sprout *d c*, to fix itself below in the Ground; after which it changes its Course as soon as ever this Root becomes strong enough to draw its Nourishment from the Earth; and

then on the contrary, taking its way upwards, it causes the *Pluma e* to shoot forth in order to become a Trunk.

SECT. IX. *The Seed-leaves, and their Use.*

IT is remarkable, besides all this, that in most Seeds, when the Root is big enough to feed the Plant, these Seed-Particles *aa, aa*, are carried upwards with the Trunk out of the Earth, after which they compose the *Seed-leaves*, so called, because these first Leaves, in almost all Plants, have a different Figure from the subsequent Leaves of the said Plants. This is very visible in some Seeds, as for Instance, in Cucumbers, in which the Seed itself, with its white Colour, does first appear above Ground; and afterwards by little and little, becomes visibly yellow, and then is turned into green Seed leaves; the same are as many in Number, as the Parts of which each Seed consists.

We do not here dispute, whether the use of these Leaves is to communicate a more proper Food to the *Pluma*, or tender Trunk of the Plant, than the Root is capable to do at that time from the Earth, and to moisten the said Trunk with the Dew and Water of Rain, which they receive by conveying it along their little Stalks, and so hinder it from being too suddenly dried up by the warm Air; or, whether these Seed-leaves help to defend the tender Plant from other Inconveniences, after the same manner as we see where in those Grains that have no Seed-leaves, the *Pluma* encompass'd with a Membrane like a Sheath, probably for the same purpose; and of which also, we may observe two little Membranes in the great Bean, that have likewise no Seed-Bladders. At least Dr. Grew observes, that in Seeds, the Parts
of

of which springing out of the Earth, are turned into Seed-leaves, none of these Membranous Sheaths are to be found. We shall not determine any thing particularly in all these Matters; but that these Seed-leaves are absolutely necessary in preserving and nourishing of the Trunk, and for the encrease of the Plant, is plain enough from the Experiments that the learned *Malpighi* has made concerning them, from whence he finally draws this Conclusion; *The Effects and Uses of these Seed-leaves are so necessary, that if they be pulled off and separated from the Plant it won't grow; and if it should any ways increase, it won't be compleat, but remain always defective.* [See his Treatise de Sem. Veget. p. 16. of the London Edition.] Every one may likewise make the same Observation.

SECT. X. Concerning the Expansion of the Seed Plant, with an Experiment of Mr. Dodart thereupon.

THEY that will be pleased to consider what we have said before relating to Beans, and particularly, concerning the little *Pluma*, with its Root, or otherwise the Seed-Plant, before it shoots out in the Earth; and they that will farther take the Pains to read what those Principal Enquirers into Nature of later Ages, such as *Malpighi*, *Grew* and *Leuwenhoek*, have writ about it; or rather those, who after their Example, have consider'd it all with a good Microscope, will know, that not only in all Beans, but also in all other Seeds that have been yet examined, there is such a little Seed-Plant to be found, in which all the Parts of the Plant that are to proceed from it, are involved or rolled up as it were like a Cléw of Thread; which being afterwards filled and expanded by Nutricious Juices, becomes an entire and compleat Plant, whether it be a Tree, a Shrub, or a Flower.

To give some farther light into the Structure of such a rolled up Seed-Plant, and upon the Account of the Wonderfulness thereof, I have transferr'd one of 'em from the *Memoirs of the French Academy* for the Year 1700. p. 187, and 188. [See Tab. XVIII. Fig. 8.]

In the said Memoirs Mr. *Dodart* says, that above 20 Years ago, he had communicated to the Academy such a Seed-Plant, as it appeared in the above-mentioned Figure, when it was scarce come out of the Earth, and had only the Bigness of a great Pin a Line or 12th Part of an Inch under its Point. He adds, that having viewed this little Ear of Corn with a convex Glass, the Focus of which was half an Inch, they could discover all the Seeds in it, and the Stalk or Trunk itself among those little Seeds, of the heighth of a Line and a half; they could likewise distinguish therein the Knots of the Straw; but all had a very different Proportion from what we see in a full grown Wheaten Plant. The Leaves, which do scarce otherwise make the sixth Part of the heighth of the Plant when compleat, were now above 18 times longer than it; the little Ear made about a third Part of the entire heighth, whereas, when the Plant is perfect, it hardly comes up to the 48th Part; the little Body of it was about 3 times as long as thick, tho' when full grown, the heighth is incomparably much greater, with respect to the Thickness; the little Tubes that compose the Straw or Stalk with their different Knots, appear to be thrust within each other, like the Pieces or Parts of a Telescope when a Man puts it into his Pocket. The Seeds were round, like perfect little Pearls, and half transparent: To form a more compleat Notion of them, you must suppose in the said Fig. 8. that A is a part of the Root from which this little Plant

is separated ; B C D E is the Tube of the Straw ; of which B is the first Part, between two Knots, C the second, D the third, E the fourth. Each of these Tubes; of which the whole Straw was composed, bore a Leaf, which is stripp'd off, to the end, that the Ear that would have been hid by those Leaves, might more plainly appear. F is the last Leaf, which leaves the Ear sufficiently naked. Finally, G is the little Ear, having already attained its compleat Figure in the middle of the little Sprout.

Now can any one observe this whole Contexture of the future Plant, in so small a Body, without amazement ; and pretend to ascribe the same to Chance or Ignorant Causes ?

The Gentlemen of the *French Academy*, having made use of some Microscopes that magnified the Object much more than the above-mention'd, have observ'd in much smaller Seed-Plants than the aforesaid Ear of Corn, how the Parts of the future Plant were adjusted together, which in shooting forth extricated themselves from each other.

SECT. XI. *Whether the Seed-Plants contain all the following ones.*

SEVERAL famous Men have gone so far in this Matter, that by seeing in each Seed its future Plant, some of 'em have maintained, and others, to use a softer Word, have conjectured [See Mr. *Dodart's Memoire* in the *Transactions* of the *French Academy*, 1701. p. 315.] that it was not improbable, that this Seed contained in its little Seed-Plant another Seed with another Seed-Plant, and so continually forwards; from whence then this Consequence must be deduced, that every Seed, how small soever it is, does actually contain the

the Seed-Plants, and their following Seeds, of as many Trees, for Instance, as might be produced from this one Seed to the end of the World ; and consequently, that all Kinds of Plants whatever, of the same Sort that were to be produced in all the following Ages, were already actually formed in the first Seed that was created ; by which they understand, that tho' the Imagination of Men cannot possibly represent to itself such an unconceivable Smallness and Number, yet the Incomprehensibleness of the Works of an infinite Creator, may be thereby set in a clearer Light, to the reproach of them that deny him ; *since* (as Mr. Dodart says in the aforementioned place, and which is also the plain Truth) *those that are accustomed to exercise themselves in Natural and Mathematical Sciences, know, that they can seldom go far without meeting something infinite ; just as if the Author of Nature and of all Truths, had been pleased to fix the Seal of his chief Property upon all things.*

I leave these Opinions, which do not seem strange to several Great Men, to their own Weight : But forasmuch as the said Mr. Dodart is pleased to bestow upon them the Title of *Conjectures*, as they really are ; and since we endeavour as much as is possible to abstain from all Uncertainties, tho' never so probable, because there are Experimental Truths in abundance, which prove a God, and a Divinity of his Word, we shall not lay any farther stress upon this Hypothesis.

SECT. XII. *Transition to the Roots and Trunks of Plants.*

WHAT we have now said about Seeds, seems to be abundantly sufficient to bring any one that has hitherto denied a Divine and Omnipresent Power, by which the Operations of all things are directed, to more reasonable Thoughts : But to shew how this Providence proceeds in all things, we should add something concerning the Roots within the Earth, and the Bodies or Trunks of Plants as they grow out of it. Now, how the Nutricious Juices are drawn or insinuated into the first from the Earth, and how by rising or circulating therein, they cause the Trunk to grow out of the same, we shall not here relate ; forasmuch as that which has been said of it, is not founded upon sufficient Certainty, and all the Experiments that have occur'd to me in order to prove the same, are still but too defective. They that desire to see any farther Account thereof, may consult the learned Opinions of *Grew*, *Malpighi*, and others ; and they that will only take the Pains to follow the Methods of those and other Enquirers, and view the things with their own Eyes thro' a Microscope, when they see a Tree or a Plant grow, and after that, consider the Structure of the Roots and Trunks, will never be able to perswade themselves, that these Bodies have acquired their Form by meer Chance.

SECT.

SECT. XIII. *The Structure of the Root and its Parts.*

NOTWITHSTANDING the many different Conjunctions and Dispositions that these Parts which compose the Root have among themselves, yet in almost all those that have been examined, we find the following Analogy and Agreements, according as Dr. Grew has described them ; namely :

I. The external Part of the Root is a Membranous Matter or Bark, consisting partly of a great Number of little Bladders like a Sponge, or rather like those Bladders which we see lying upon one another when we blow with a Pipe in Soapy Water ; and partly of a Ligneous Matter or Fibres, that are so many little Tubes. The first Kind are visible through a Microscope ; and the last are seen in some Roots, such as *Scorfonera*, and others from the Experiments quoted by the said Dr. Grew, in the 2d Chapter of his *Compar. Anatom. Radic.*

II. The second Part, which composes the Root, and lies under the outmost Skin of all, is the Bark ; (*Liber.*) and this likewise consists of two Kinds of Bodies, the first of which is also a Collection of roundish Bladders, which, being dried, shrink in like a Sponge, but when steep'd in Water, swell out again. Among these little Bladders there are mingled several Vessels that convey the Sap, of which some contain in themselves a watry Humour, some a milky, and others of other Kinds ; and they represent very different Forms, as they are disposed among each other.

III. The third Body that we meet with in the Bark, in the Roots, does likewise consist partly of the same Bladders, that are interwoven with those

those of the Bark and those of the Skin ; and partly of Tubes or Vessels that compose the Woody Part of the Root, and some of 'em contain Sap, and others only mere Air. These are likewise disposed after various Manners, in different Roots.

IV. The inmost Part of the Root is the *Marrow* or Pith, which is found in some, but not in others. This likewise consists of little Bladders, and of the same kind of Body as we have described before in the Bark, and in the Woody Part of the Root: 'Tis often only a Vessical Matter, and sometimes 'tis mingled with Woody Fibres, or with the little Tubes that convey the Sap and Air.

SECT. XIV. *These Dispositions represented in the Pepper-Root.*

THE Dispositions of these Parts do sufficiently appear in many Roots to the naked Eye, if they be cut across; but much plainer thro' a good Microscope, and we find 'em very accurately delineated both ways, by the said Dr. Grew.

I shall produce one here (*Tab. XIX. Fig. 1.*) in which, thro' a Microscope, part of a little Slice of the Pepper-Root appears, after the following manner: The outmost little Bladders A A, represent the Skin and its external Membrane; from thence to B B is the Bark, in which the Vessels that carry the Sap may be seen between B and L, representing inwardly a broader, and outwardly a narrower and more acute Composition: Between B and G we may observe several Kinds of Orifices of the Air-Tubes; and between G and E, another little circle of other Vessels that carry Sap, in which from E to K is the Pith; the little Bladders in the Skin, in the Bark between the Sap-Tubes thereof, and between the Air Vessels

fels too, and lastly in the Pith, are all of 'em, according to their different Sizes, visible enough.

SECT. XV. *The Structure of the Trunk in an Ash-Tree.*

THE Trunks of Trees and Plants do consist of much the same Parts as the Roots, namely, of vesfical Globules, and various Tubes for conveying Sap and Air. Thus it has been observed by *Malpighi* and *Grew*; but however in a different Disposition and Proportion in respect to each other, than in the Roots, and in several Plants with a very great Diversity, as to Size, Number, Place, &c. as may be seen in the said *Grew's Comparative Anatomy of the Trunks*, in many Instances, but not without Astonishment.

One Example we have produced from him here in *Tab. XIX. Fig. 2.* in an *Ash-Tree*, the fourth Part of the Trunk whereof is represented as cut across: *ABCD* is the Bark; of which *AB* is the outmost Skin, and *AHB* the Sap or ligneous Tubes ranged by one another in circular Dispositions next to the extreamest Skin; *II* is the vesfical Matter of the Bark, which below at *D* and *C*, has another kind of Sap-Vessels, disposed in an arched or curved Order; *DCFE* is the Wood; *DQLK*, *KL MN*, and *MNFE*, are the fourth part of three circular Superficies, each composing a great Tube from Top to Bottom, in such manner, that one of 'em grows every Year about the Tree; the real Wood is *SSS*; between *S* and *T* are the round Orifices of the Air Vessels, which are dispersed thro' the whole Wood, being larger in the inmost Part of the Circles *KL*, *MN*, *EF*, and lesser in the outmost; *EEG* is the Pith; *ee* the Bladders thereof; and *Oo Oo* are the *Insertions*,
in

in which the Vessical Textures of the Pith and Bark have a Communication with each other.

Hitherto these abovemention'd Naturalists have only discover'd a vessical Structure, and ascending Sap and Air Tubes ; but *Lewwenhoek* has likewise discover'd Vessels therein that run horizontally ; and whereas the Figures of *Malpighi* and *Grew* do represent in general the Trunk and Root, and the Parts and Vessels of which, according to their Remarks, the same are composed ; we may yet farther understand the Kinds of those Vessels as they have been observed with great Accuracy by the said *Lewwenhoek*, and drawn by him from the Life.

SECT. XVI. *The Trunks grow upwards and the Roots downwards.*

NOW if ever there occur'd in Nature a surprising Phenomenon capable of obliging the most obdurate Atheist to acknowledge, that in the growth of Plants, a wonderful Wisdom, Power and Goodness, has had its own Ends in view, and has carried 'em on even contrary to the Imagination and Opinion of Men, 'tis certain the same is here displayed most evidently, and after such a manner as has hitherto been inscrutable even to the greatest Philosophers: The Wonder which we are ushering in with so much Pomp, and upon which such famous Naturalists as the Gentlemen of the *Royal Academy of France*, do likewise bestow the name of *Wonder*, in their *Histories for the Years 1700*, and *1702*, is that Law to which we see so many Trees and Plants incessantly subservient: According to which the Roots of all Seeds are for ever found to grow downwards, and the Trunks thereof to grow upwards.

SECT. XVII, XVIII, XIX. *Three Experiments made upon Beans, Acorns, and other Trees.*

To give an Idea of what we have just now said very briefly ; it is known, that in all Seeds there is not only a little beginning of a future Plant and Root, as may appear from the Beans, &c. ; but we likewise find, that the *Pluma* and Root-Sprout of which we have treated above, have a determinate Place in all Seeds, out of which they shoot at first according to a determinate Course ; but when they proceed, we always see that the Trunk ascends and the Root descends into the Earth. They that desire to make a Tryal of it, may imitate that of Mr. *Dodart*, a Member of the *French Academy*, with very little Pains and Trouble ; I my self have done it with several Beans, and to my great surprize found it not to fail in any : 'Tis thus, if you split a Bean (*Tab. XVIII. Fig. 9.*) and separate two Lobes or Pieces of which it is composed, from each other, having first steep'd the said Bean 24 Hours in Water, and then dried it as long after, till it begins to shoot out as at 2, which will be the Root, you will see at 1 the *Pluma*, which is to be the Trunk lying in a hollow Place on one side ; and in the other at 3 another little Cavity, in which the *Pluma* is likewise preserved : If then you take another of these Sprouting Beans, and Plant it as at A, so that the Root 2 extends itself downwards, it won't seem strange to any one that the Root-Stalk 2 (*vide B*) shoots downwards, and the little Trunk 1 upwards, forasmuch as the Situation of both of 'em do naturally tend thereto. But it will be very surprising, when one takes the Bean C, and lays it upon its side flat in the Earth, that the Root 2, and the Trunk 1, do not grow horizontally, which must have

have come to pass, if they had continued the preceding Course, as the Bean seemed to determine it; instead of which we discover, that both the Root 2, and the Trunk 1, make a Bow or a crooked Line, in order to proceed downwards and upwards: But to come to the utmost; can a Man see without Astonishment, that when he plants the Bean invertedly, that is to say, with the Root upwards and the Trunk downwards, yet the Trunk 1 winds itself about the Root upwards; and in like manner the Root 2 making a Semi-circle about the Trunk or Plume, takes its Course downwards. Now that these Figures may not appear somewhat improper, it is to be observed, that the little Trunks 1, 1, 1, at B, C, D, are drawn here before they were so old that they could properly make their Appearance in the Air. See the *Memoirs of the French Academy* 1700. p. 18. Now that this does not only happen in Beans, is shewn by the said Mr. Dodart, in the *History of the French Academy*, 1702. p. 62. That Gentleman found in the Month of *December*, some Acorns lying in a heap upon a moist Place where the Ground was firm and compact, as in a beaten Path: Many of these Acorns had shot out their Root in the Air without being in the Earth, and their little Roots came all of 'em out of the Point or Top of each Acorn, having the length of from 4 to 18 Lines, or 12th Parts of an Inch; and that which was wonderful was, that every one of these Roots bent themselves the shortest way towards the Earth, as if they all sought for it. This was therefore the more strange, because he did not observe any of the Acorns, whose Points tended downwards, so as that if they had grown streight out they could have reach'd the Earth, but on the contrary, he found one Acorn among 'em, the Point of which grew upwards, and in that he saw that the Root

shot streight up about an Inch in length, but that it afterwards changed its Course, and as it grew turned downwards to the Earth.

This then gave him a handle to make the following Experiment : He took six of those Acorns, and set 'em in a Flower-pot, after the manner as you may see in *Tab. XVIII. Fig. 10.* at A, that is with the Point streight upwards, so that the Roots that were to spring from 'em seemed not capable of growing any other way than upwards ; he cover'd them with Earth of about two Fingers thick, and let 'em remain in the Pot the space of two Months, in which time they had shot out, and the Root having now acquired some length, made close to the Acorn an Inflection and Turn ; and so in the rest of the Acorns they grew down again, seeking as 'twere a depth of Earth, just in the same manner as at B : And now the Consequence certainly seems to be, that all these Roots having once taken this Course of growing backwards from the Point to the Tail, they would persist in it and pursue their Course again right forwards ; for which reason he took these Acorns and inverted 'em again, pressing the Earth down quite round 'em, to the end that it might touch every Part ; so that they stood as at C, with their Root now turned upwards, which before at B tended downwards. In this Condition he left 'em two Months more, and the Event was, that having uncover'd them, he found that there was nothing less than their growing upwards, but that each of 'em had made a second and new Inflection or Elbow, as at D ; in order to make their Roots, as it were in spight of all these Obstacles, sink down deeper into the Earth, where they must be if they would perform any Service.

The said Mr. *Dodart* relates a great many of the like Accidents with respect to Trunks, as he had done

done before concerning the Roots of Acorns ; viz. That finding some Trunks of young Pine Trees, thrown down to the Ground by a Storm, at a place call'd *Chauville*, some lying upon a greater Steep or Slope, others upon a lesser, as in *Tab. XVIII. Fig. 11.* of which all the extream Parts *a d*, *b f*, *c g*, grew streight and perpendicularly upwards ; insomuch, that those that fell upon a greater Obliquity as here at *E c g*, in order to ascend directly, were forced to make a much more acute Angle than the uppermost *D b f*, and *C a d* ; which lay in Places the Declivity of which was not so great : The like we may observe in many Branches of Trees, when they are hinder'd by any Violence from growing upwards ; so that likewise Weeds, that spring out of the Sides of perpendicular Walls, after running a little horizontally, extend their Trunks upwards again ; and even when some of 'em are not stiff enough to bear their own Weight horizontally, insomuch that they are thereby pressed downwards, we see, that when the Trunk becomes stronger, they will make a little Inflection, and then grow upwards. The first Instance thereof appears in *Tab. XVIII. Fig. 12.* at *A*, and the second at *B* ; of this I observed not long since a wonderful Example in an Elder-Tree, growing out of the little Crack of a Wall.

SECT. XX. *Convictions from the foregoing Observations.*

AFTER having consider'd this whole Matter, and particularly what has been said about *Beans* and *Acorns*, who can conceive the Reasons thereof ! And if we do not ascribe it to an adorable Providence, which executes its great and wise Ends by means as yet unknown to Men, to the Confusion of its Enemies ; then let any Body furnish us experimen-

tally with a true Cause that may be sufficient for this Purpose ; and shew us what Mechanical Operations and Laws are known to him in Nature, from whence we may plainly deduce this Phenomenon in all its Circumstances.

The Gentleman who made these Experiments, and so carefully observed all these things, was not ashamed to record the Weakness of his Understanding, and the Insufficiency of his Argumentations, immediately after the Relation thereof, even in the *Memoirs of the Royal French Academy*. I shall not here relate all the Reasons that are there collected, to shew the Nothingness of all the Hypotheses hitherto laid down ; any Body that has a mind may see them there himself. But I cannot here forbear to take notice of the noble Acknowledgment of an Adoreable G O D, which the worthy Author subjoyns upon this Occasion ; and which such great Philosophers, as are the Members of that Academy, have permitted to be so emphatically expressed : For Mr. *Dodart* having in the said *Memoirs* for the Year 1700. p. 72. suggested all that is yet unknown, and that seemed requisite in order to trace in some manner the true Cause of this Effect, concludes his Discourse in these Words : *I know nothing of all this, and chuse rather to wonder at a certain continual and amazing Phenomenon, than to flatter my self, with imagining that I know something of that, of which I know nothing at all. I confess I would very willingly discover the Cause thereof, but my Ignorance will not suffer me to enjoy a Pleasure which would overpay the loss I suffer by not understanding the Natural Cause of so wonderful an Appearance ; for this Darkness and Ignorance in which I find my self, makes me see, and even makes me palpably sensible of a Supream Cause, whose Wisdom and Power infinitely surpasses not only my Thoughts and Conjectures,*

but

TAB. XVII.

Fig. 2.

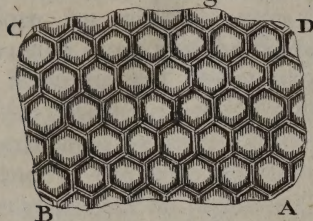


Fig. 3.

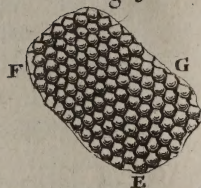


Fig. 6.

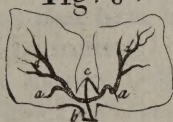


Fig. 5.



Fig. 7.



Fig. 4.

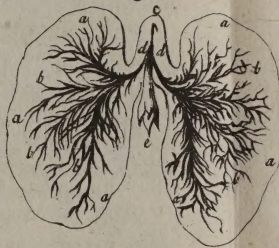


Fig. 1.

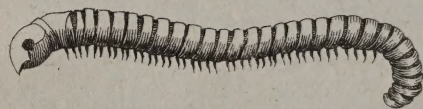
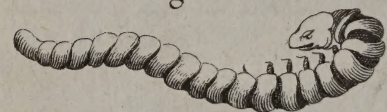


Fig. 10.



Fig. 9.

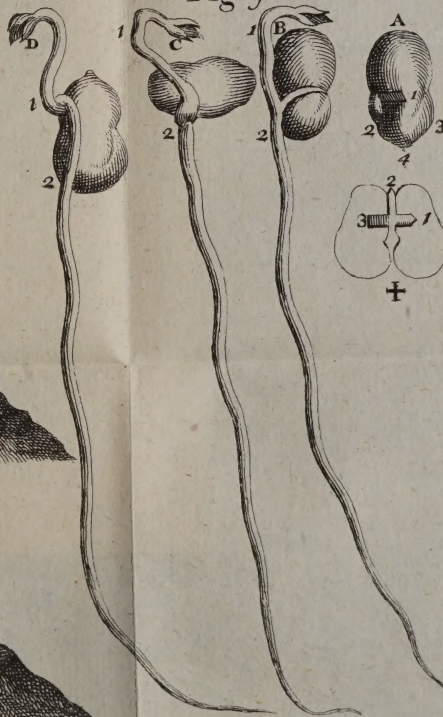


Fig. 8.



Fig. 11.

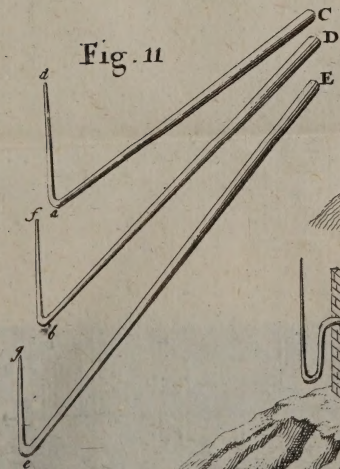
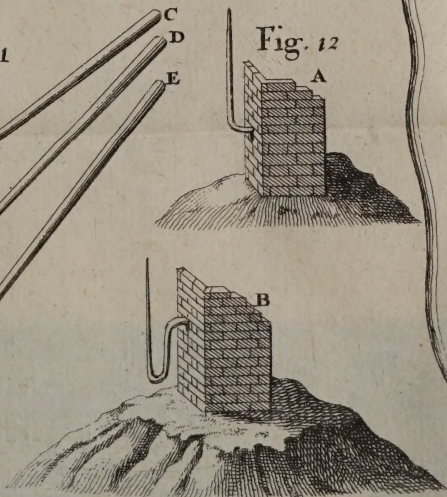


Fig. 12.



but also those of all Men of the quickest Apprehension and Judgment that ever were or ever shall be.

Now let the Atheist tell us, whether he ever durst maintain, upon seeing a ploughed Land full of Corn, by which his own Life, and the Lives of so many more must be supported, that the Plowing, Sowing, and Preparation of that Ground, and the Production of the Corn from thence, was all performed by mere Chance, without any Concurrence of the wise Husbandman ; and yet can he imagine that he argues rightly, when he asserts, that what we see happening to these Seeds in their Growth (and without which all the Pains and Charges that have been bestowed upon the Land would be fruitless) can be ascribed to a Cause that neither knows itself nor any of its Operations ? For unless Providence had been pleased to take so much Care, that the Roots of all Seeds should tend downwards to the Earth, and the Trunks or Bodies upwards, tho' the Seeds themselves were thrown into the Earth, either horizontally or invertedly, it won't be necessary to prove, that every thing that lives by Sowing being deprived of its Nourishment, would soon perish : Since, by far the most Kinds of Grain, and all other Seeds that are strewed and sown either by the Hand, or by Wind, as most are, it is hardly credible, that one of them should fall in such a Posture as to shoot forth its Root directly downward, and its Trunk upward, and yet this is requisite if they grow as they should.

SECT. XXI. *The Knots and Buds of Plants, and Convictions from thence.*

WE don't think it necessary to transfer hither all the Observations which the Naturalists have made upon the Texture of Plants by the help of their Microscopes, since we don't pretend to give an entire History of *Botany*; wherefore those that desire to contemplate the numberless Wonders that occur therein, and which do uncontestably demonstrate the Power of GOD to such as are any way reasonable, may be pleased to consult what Messieurs *Malpighi*, *Grew*, *Lewwenhoek*, and others, have writ concerning the same; we shall only say a word or two briefly about them: Now they that have seen before the Texture of the Roots and Trunks of Plants, if they should take a yearly Sprig of a Tree into their Hand, can they think it happens by Chance, that it is furnished round about with Knots or Buds so exactly placed at a due Distance from each other, which Knots are the Source or Beginning of Fruits or other Branches! but particularly, can any Body see without Astonishment, that each of these little Knots does regularly spring from the inmost Part of the Branch, and that the Structure of the ligneous Fibres and little Bladders of the Branch are ranged so nicely in this Form, that upon the putting out of the Branch, the Knot or Bud that is composed of the same Matter with it, may likewise shoot out!

Besides all this, one of these little Buds only may seem sufficient to make any one who seeks for a GOD to find him therein; let him but contemplate in the 74th Figure of *Malpighi*, *Cap. de Gemmis* (and which is transferr'd hither in *Tab. XIX. Fig. 3.*) the Structure of an Oak-Knot, where

where are represented at A some of the little Bladders of the Pith of the Twig, which you may observe to be surrounded with ligneous Fibres at B ; C is the Bark, the Fibres of which do further compose the Leaves D of the Knot. So that all Knots consist of the little small Sprig A with its Bark, ligneous Fibres and Bladders; and the said Sprig is preserved by little Leaves lying upon one another like Scales, and incompassing it round about.

In the Bladders of some of these Knots (for almost all of 'em differ from each other) are little Nipples or Globules, containing in them a terebinthinous or glutinous Matter.

These Knot-Leaves, if we trace their growth, do appear in many Plants gradually longer, and in time are changed, shooting out into Stalks of the following Leaves, which cloath the Branch proceeding from thence. How wonderfully this happens in several Plants, may be seen in *Malpighi's Anatomy of Plants*, p. 26, &c.

Wherefore the said Gentleman having observed all this with an unwearied Diligence, justly concludes, that the Sprout of the Knot does already comprehend the future Branch in Miniature. This will appear so much the more plain, if one reads the fifth Continuation of Mr. *Lewwenhoek*, who says, that in the Bud of a Currant-tree, even in Winter, he could discover not only the Ligneous Part, but likewise the Berries themselves, appearing like small Grapes, and that the said Ligneous Part or Stalk shot out exactly at that place where the Bunches of Currants first appear. B C D *Tab. XIX. Fig. 4.* are the two Bunches of Currants, and E F G the young Sprig or Branch, according as the said Mr. *Lewwenhoek* has describ'd them.

Now if any one can believe, that this Stamen or Principle of a Plant, which discloses itself in

these Buds roll'd up in a Space so unspeakably small, and with so much Regularity, is to be ascribed to mere Chance, why does he not maintain the same of the finest Watch that was ever made ?

SECT. XXII. *The Structure of the Leaves, and their Usefulness.*

How the Leaves of the Branches proceed from those of the Knots, we have in some manner shewn above : They consist of the same Parts with the Trunk and Branches, and have Wood and Sap-Vessels of several Kinds : Thus the Sap in the *Tithymallus* and others, is white ; in the *Chelidonia* yellow, in others, of other Colours ; and each of 'em have their Air-Vessels.

The Wood, or Air and Sap-Vessels being collected in the Stalks, spread themselves out in the Leaves like so many Branches of little Trees, and these compose the Ribs of the Leaves, which in some Plants are knit together Reticularly or Net-wise : Between them are the little Bladders which make the Thickness of the Leaves ; in the upper Superficies of some Leaves, we find little Orifices which proceed from internal hollow globular Bodies, and through which perhaps there exhales either a Vapour or liquid Matter ; to which Matter proceeding from the Leaves of Trees, may perhaps be referr'd that which is said in the *Memoirs of the French Academy*, 1707. p. 62. at least, *Malpighi* affirms, that these Cavities may be plainly seen in Chestnut, Popler and Mulberry-Trees, when the Bladders that are in the Leaves are dried up. The XIXth Table represents in Fig 5. how the large Rib A sends out little Branches B through the Leaf, which, with other Branches C, that proceed from them, make up those Reticular Interstices

stices, which here in the Figure appear Blank, in which may be seen the hollow globular Bodies D, opening externally. In these white Interstices there are likewise little Bladders E, disposed orbicularly, and which often make such a Cavity as F, out of which there filtrates a kind of a glutinous Liquor. Now, whether all this happens by Chance and without any Wisdom in such a Number of Leaves in each Tree, together with the Changes in all of 'em so necessary to the well-being of each in particular, one may safely submit to the Judgment of any reasonable Person ; the rather since we see that these Leaves are so exceeding necessary to the Trees, that when they are robb'd of the same too early by Caterpillers, or other Causes, they can bring no Fruit that Year to Perfection. Now, whether these Leaves do render the Sap and Juices of Trees and Plants more proper to fructify, or whether they contribute any otherwise to the well-being of the Plant, since they seem to extend their open Arms as it were towards Heaven, to receive the Dews and Rains thereof ; and to derive them farther for other uses, we cannot yet determine ; this at least is probable, that in many Leaves the little Stalks are contrived more or less gutterwise, so that the Dew and Rain falling upon the Leaves, may run along them, and be conveyed to the little Knots (which are often found in Trees, in those Parts where the Leaves spring out) in order to moisten the same, other Stalks are round, along which the Water can creep well enough from the Leaves to the Knot, but not in so great a Quantity : So that these Leaves seem at least to serve to supply each little Knot with Water. Will any Body pretend, that this likewise is to be ascribed to Chance ?

We

We likewise see that the Juicy Fruits that are in danger of being dried up too soon by the heat of the Sun, such as Mulberries, Strawberries and Currants, are furnished with Leaves larger than themselves, to the end, that they may be cover'd thereby ; and that Apples and Pears, that are more solid, and require a stronger influence of the Sun, have smaller Leaves, tho' their Trees are often bigger.

Besides all this, since the Leaves do shadow the Tree, and since we have shewn above in *Contemplation XIX.* that this is the Cause that the Air with its watry Parts, is continually driven towards it ; we may likewise observe from hence, that the great and adorable Preserver of all things, has, by the means of Leaves, imparted to Trees such an Advantage, that tho' no Wind should move the Dew and moist Vapours of the Air, yet through the greater Coolness of the Shadow, the external warmer Air being condens'd and driven thitherwards, carries its watry Parts with it to the Trees, and continually moistens the same.

SECT. XXIII, XXIV, and XXV. *Several Experiments to shew the Perspiration of Leaves.*

I SHALL not here enquire, whether with all this, the Orifices likewise which *Malpighi* observed to be in the Leaves, may not perform the same Functions in Trees as the Pores of the Body do in Men, that is to say, to cause an invisible Perspiration : This the Perfumes and Scents which we find in the Air under many Trees, seems to render very probable : And the same is likewise corroborated by the Experiment of *Mr. de la Hire* in the *Memoirs of the Royal French Academy*, 1703, p. 73. this Gentleman, in order to try whether Fountains could be produced by Rain only (ac-
cording

cording to the Opinion of Mr. *Marriote*) had a mind to try how much Water was necessary to the growth of a Plant; for which reason upon the 30th of *June*, about five in the Morning, he took two fresh-pluck'd and solid Fig-Leaves and thrust their Stalks in a Bottle that had a narrow Neck, and which was filled with Water, so that the end of the Stalks might touch it; then he closed the Mouth of the Bottle so carefully, that no Water could evaporate from thence, but thro' the Stalks; having weighed the whole, he set it in a place where the Sun shined, and where the Wind did blow a little. The Fig-Leaves alone weighed 5 Drahms and 48 Grains; at eleven a Clock, he found that the whole was lighter by two Drahms on account of the Particles that were drawn out of these Leaves by the Air and the Sun; having likewise found in other Plants, of which he had made tryal, always a great Evaporation of Moisture. But he has not taken notice, whether the Water which at first weighed a Pound, was so much diminished, or whether the Leaves were so much dried up, or, whether the loss happen'd partly to both; however, he proves from thence, that there was a sensible Perspiration thro' the Leaves: Which may likewise be concluded from the Experiments of *Dr. Woodward*, mention'd in the *Philos. Trans. Num. 253*. So that it appears from hence (at least it seems so) that the Leaves, besides other Uses, do likewise serve for the Perspiration of Plants.

I should now have passed on to something else, did I not think that (in order to give some Light to the so obscure Structure and Oeconomy of Plants, and thereby render the adorable Wisdom of the Creator, the clearer in so many of 'em, and to understand the Nature of 'em with greater Certainty) the following Experiments might perhaps be of some use.

I find

I find among my Notes for the Year 1696, that upon the 21st of *January*, we cut a little piece of a *Radish*, and another from the middle Rib of a *Colwort-Leaf*, and a third of a sower *Oak-Apple*, and put each of 'em into a particular Glass, fastening 'em at the Bottom with a Brass Wire, and then fill'd the same with a strong Lye made with Water and Pot-ashes, filtrated thro' a Paper; then setting them all under the Receiver of the Air-Pump, we observed, that upon taking away the Pressure of the Ambient Air, a great Quantity of Air ascended from each of them, particularly from the sower *Oak-Apple*, which produced a perfect Froth upon the Superficies of the Lye (we shall not here inquire, whether this last might not be increased by the fermentation of the Acids of the Apple with the Salts of the Lye) and every time we exhausted the Air the same Effect followed. The reason why we made use of Lye rather than Water, was, that it might not be objected, that the Air which is oftentimes found in Water, might contribute something thereto; tho' even in Water also, and before that the Air is boiled out of it, the thing appears so plain, that no Body, who is not too scrupulous, need make use of Lye.

On the 2d of *June*, 1696, we took two little pieces of the Branch of an Elm, and put 'em both into the Lye and under the Receiver, one of which was placed with that End upwards that grew next the Trunk of the Tree, and t'other in a contrary Position; then exhausting the Air, we observ'd that a great many Air-bubbles ascended equally out of the Bark of each of 'em; but that out of the middle of the Wood, the Air flowed as it were in an entire Stream, both at the under and upper End; and when we cut away a little of the Bark from the Ends, we observed the same, as also when we put in Wood without Bark, and Bark without Wood, the Air came out very strong-

ly from both. About a Week afterwards we took a single *Asparagus* that had been two Days out of the Earth, cut it to pieces, and observed a great deal of Air to come out of it, but nothing near so much as what came out of the Elm-Twig; most of the Air came likewise out of that End that stood upwards in the Earth: There appeared some little Bubbles at the other end, and some came also, but not many, out of the sides of the *Asparagus*.

On the 7th of *June* 1709, we tied a little piece of a Branch of a Morello-Tree to two Nails, and fasten'd 'em with a Thread to the Hook of the Receiver of the Air-Pump; so that being put into a Glass full of Water, it hung about three Fingers breadth under the Surface of it.

After that, we took a little piece of the Stalk of the Flower called the *Imperial Crown*, and tied two Nails to it likewise, to make it subside in the Water; then drawing off the Air, we observ'd a whole stream of Air rising upwards out of both; from whence it appears, that the Stalks or Trunks of Plants do contain a great deal of Air in them, and what was before discover'd by the Microscope, is hereby confirmed.

To examine into this Matter a little more strictly in Leaves; we tied five Morello-Leaves together by the Stalks, and then cut off about half of 'em, to the end, that the Tubes or Canals in their little Ribs being open'd, the Air might more easily be drawn out of them; then putting them into a Glass of Water after the same manner as before, we could observe scarce any Air to come out of the Sides of the Leaves that had been open'd by cutting, but the Superficies or flat Parts of the Leaves were cover'd with clear Air-bubbles, insomuch that those Bubbles swelling bigger by our continuing to pump, the Leaves and the Nails to which they were fasten'd, rose up to

the Top of the Water ; but upon letting in some Air again, the little Bubbles disappeared as usual, and the Leaves subsided.

From hence likewise it seems to follow, that Leaves perspire very much, and that their Pores are more numerous than those of the Stalks or Trunks of Plants. There was likewise this remarkable difference between the Leaves and Trunks, namely, that the Trunks did indeed emit whole Streams of Air from their open Ends, but that there were none, or very few, Air-bubbles externally upon the Bark : Whereas on the contrary, there seemed to be very little Air flowing from those Parts of the Leaves where they were cut, but a great many Bubbles upon their Superficies.

Perhaps by comparing all this together, there might be a Foundation for a probable Hypothesis, to shew the manner how the Sap is circulated in Plants, namely, by the Rarefaction of the Air, in the Day-time, when 'tis warmed by the Sun, and by the Cessation thereof in the Cold of the Night ; but this is not our Purpose here, and a greater Number and Series of Experiments would be requisite to confirm the same. Our view in mentioning these Matters, is, *First*, to shew that we ought not to doubt of what has been advanced concerning the Plants by those Gentlemen that have examined them so far with Microscopes : And, *Secondly*, to open a way whereby the Manner of Growing, and the Circulation of the Sap in Plants, may be traced after another manner than by the help of Microscopes ; and thus by using different Methods to discover these surprising Wonders of the Creator, a greater progress may be made for his Glory and Honour.

SECT. XXVI, and XXVII. *The Structure of Flowers, with their Supporters, and without.*

IF we pass from the Leaves to the Flowers, which consist of the same Matter as all other Plants, *viz.* of Air and several Sap-Vessels, otherwise termed Wood-Vessels, and of a vessical Structure, besides which, we find that most Flowers proceed from a Bud or Knot (which the Florists call the *Calyx*) the Leaves or Parts of which do first cover the Flower contained therein, whilst it is yet unable to bear the Inconveniencies of the Weather, and defend it from the same; and after that the Flower is blown, they keep up its Leaves, that they may not hang confusedly together, but regularly represent their Beauties to the Eyes of the Beholders. Let us contemplate a Coronation, for Instance, and see first how its green Bud secures the Leaves of the Flower, and then keeps together the little weak Stalks thereof, that it may nourish the Seed; and moreover, how it is indented at Top in order to close the Flower the better while it is in Bud, and afterwards to spread out more largely in order to Support the Leaves more strongly. Let us observe the same in Roses, and a thousand other Flowers, all which are furnished with such a Calyx and Supporters proceeding out of it, some with one circular Leaf, as is the Coronation, others of more, as the *Roses*, others of little Leaves lying upon one another, like the Scales of Fishes, as the *Cyanos* or *Corn-Flower*; others, after infinite other Manners, yet all serving for the same Use; so are the Artichocks made of such Cups only, with Leaves lying upon one another.

Now since these things (all concurring to the same End in such an infinite number of Flowers)

cannot be ascrib'd to mere Chance, to the end, that no Body may deduce the same from an ignorant Necessity flowing from the Structure of all Flowers, since this happens in almost all that stand in need of being preserved in the Bud, and of being supported when blown, we shall see, that in all Flowers the Leaves of which are strong and powerful enough not to want such Supporters, such Cups or Leaves distinct from the Flowers are not to be found at all : Of this kind are white Lillies, all Tulips and many sorts of other Bulbous or Onion-Flowers, which are cover'd in the Bud with a thin green Leaf, and when blown, support themselves by the Strength of their own Leaves only ; thus we see in Crocus or Saffron, which comes up in the Spring, and which having no *Calyx* or Bud sufficient to cover it, that it is provided with a white membranous Tegument, by which its Flower is preserved from the pernicious Effects of the Air whilst it is yet tender.

SECT. XXVIII. *Some Particulars about Flowers.*

OF the Leaves of Flowers, and of their ravishing Agreements as they affect the Sight and Smell of every Body, we shall not take any notice here, they being so well known ; only it is to be observed, that as the Cup and Leaves surround and preserve the Flowers, so likewise the Flower-Leaves do secure the Heart or inmost Part thereof, and that many of 'em are cloathed with a Down or Natural *Farina* about their Heart, in order to provide a softer and warmer Lodging for the little Sprout in the middle of 'em.

We shall likewise pass by all the wonderful Particulars that *Malpighi* and *Grew* have already noted in Flowers, such as their little Horns and little

little Hairs, their Magazines and Store-Houses of slimy and terebinthinous Matters; particularly the Places where a Sweet and Honey Liquor is separated and preserved in their Leaves. They that see this Liquid Matter gather'd by the Bees, and serving so many Purposes to Mankind, will at least learn thereby, that it is not without Reason, that he who acknowledges a Glorious GOD for the Maker of all things, may, besides the Adoreableness of his Wisdom, observe also from hence, the Greatness of his Bounty and Favour to us.

Nor shall we take upon us to describe in this place the Parts of Flowers exclusive of their Buds and Leaves, forasmuch as the same are not yet compleatly known to us; such as, for Instance, the Places in the Heart or Middle thereof in which the Seed is formed; nor yet the little Threads, nor the stiff long Excrescences that bear other little Bodies, full of a certain fine Dust at the Top of 'em, such as Lillies and the like; the former of which the Botanists call *Stylus*, and the other *Stamina*.

SECT. XXIX. *The little Threads, &c. and Convictions from thence.*

ONLY let us finally make this Remark, and ask, whether an Atheist seeing the Branches of a Vine so weak that they can't possibly support themselves, does not believe, that it is with a wise Design, that they are furnished with those Threads by which the Joynts or Knots fasten and support themselves on every thing that sticks out? and, whether he does not observe a Design therein, especially, since those Threads, after having twisted themselves about any solid Matter, are yet unable to bear the weight of the Bunches hanging upon 'em, were it not that the Matter of which they are com-

posed, was incomparably tougher than any thing else in the whole Vine.

Thus it is likewise with the Cucumbers, the Branches of which would easily be broken by the Wind were they not strengthen'd by some other Threads and Supports. If there be not a wise End and Design in all this, how comes it that the *Ivy* which grows never better than against a Wall, shoots out of its Side, as it were, little Roots or Sprouts, which having a glutinous Moisture in 'em, do thereby cleave to the said Walls, and so support such a great Apparatus of Leaves and Branches; which how wonderfully it comes to pass in the *Canada Vine*, has been described by Mr. Malpighi.

Now to convince an Infidel by some farther Instances, if it be possible, can Chance be the Cause of all things in Plants, each of which bears a Seed, from which exactly the same, and never any other Plant proceeds when sowed in a proper Ground; as for example, a Vine never produces Figs or any other Fruit besides its own Grapes.

Pears, Apples, Grapes, &c. ripen first nearest their Stalks; Figs, Mellons, Peaches, Plumbs, Abricots, &c. farthest from their Stalks.

In Coronations, Jessamin, and others, the highest Flowers, or such as are most remote from the Root come first to Perfection; in Lillies and Hyacinths, &c. the lowest; In Raspberries this happens indifferently.

The Trees of Apples, Pears, Peaches, Abricots, Cherries, &c. bear Fruit at two Years growth, but Grapes, Nuts, Raspberries, are produced the first Year.

Thus in many Trees those Leaves that are farthest from the Root wither first in Autumn; but in Pease, Beans, Artichoaks, and many others,

yea,

yea, even in Peach and Almond-Trees we see the contrary.

In many Plants the Fruit proceeds from the same Part where the Blossom was, as is well known; but in the Small-Nut, Hazle, and Chesnut-Trees, and also in *Turkish* or *Indian* Corn, the Fruit comes where the Blossom never was.

Almost all Fruits are preceded by their Blossoms; but the Fig grows perfect without a Flower; and in Melons, Cucumbers, &c. the Fruit is seen before the Flower.

In Fruit-bearing-Wood, the Fruit and Leaf are mostly together, but in Vines it is chiefly the contrary, where the Grapes and Leaves are on different Sides.

In some Trees the Branches are long, because their extream Parts are lengthen'd out, which is most usual; but in Vines, in Tulips, in Coronations, &c. the extream Part remains without shooting out farther, and the Lengthening is made by the growing of that which is below.

They that would see more of these Remarks, may meet with 'em in the Reflections upon Agriculture, of Mr. *de la Quintinye*, Ch. XVIII. and judge from thence, whether the All-wise GOD can shew more plainly, that his Power of directing all things according to his good Pleasure, is confined to no necessary Laws, than by making us see in Plants, that there is nothing in one part of 'em which he cannot produce in another, after a seeming contrary manner, to the same End and Purpose.

SECT. XXX. *The Curse of the Earth.*

THEY that have observed the Frankness and Sincerity of this famous Florist, and Director of all the Royal Gardens in *France*, in several Expressions of the aforesaid Treatise, will not be surpris'd at the blunt Acknowledgment of his Ignorance in the following Words of the XVth Chapter; *I cannot conceive how it comes to pass, that the Earth grows Weak and Lean, with respect to those Plants which are in some measure Strangers to it, as for instance, Corn, Herbs and Trees; but yet seems to have preserved its whole Strength, nor does its Fruitfulness appear by any means to be diminished, with respect to its Production of Thorns and Thistles, and an infinite Number of other ill Weeds.* Every one who makes use of his Reason and Experience, as a Naturalist, and no otherwise, will doubtless be at a loss to assign the true Causes of this Fact: I speak here of the true Cause only, because it is not so difficult to advance an Hypothesis, and from thence to deduce a seeming Effect of Nature; and we all know that there are many such laid down, of which nevertheless none come up to the Truth. We shall not here dispute about the Natural Cause thereof; but only ask an Unbeliever, when he reads the Curse pronounced against the Earth by the Creator thereof, for the Sin of our first Parents; *Gen. iii. 17, 18, &c. Cursed is the Ground for thy sake; in sorrow shalt thou eat of it, all the Days of thy Life: Thorns also and Thistles shall it bring forth to thee; and thou shalt eat the Herbs of the Field.* Whether, tho' he did not allow all these Words to be Divine, he be not obliged to own, that the Contemplation of Nature would teach him the same thing: And that it is worthy of his most serious Reflection, that the Earth, without any Diminution of its Strength,

Strength, is able of itself to produce Thorns and Thistles, and other useleſs Herbs in Abundance ; but when it comes to bring forth all kind of Grain, and other Plants proper for Food, it becomes then Lean and loſes its Fertility. Now if he does not with us deduce this from the above-mention'd Curſe, and yet will ſatisfy himſelf, and any other reaſonable Perſon ; it behoves him, *Fiſt*, to ſhew the Cauſe why this happens not only now, but has come to paſs after the ſame manner in all Ages, and in all Places. *Secondly*, If he thinks he has diſcover'd the true Reaſons thereof, it will lye upon him to prove likewiſe, that this will neceſſarily follow from the Structure of the Univerſe, and that it could not fall out otherwiſe, but that the Earth muſt needs produce Thorns and Thistles, and other Weeds, without impairing its Strength ; and that juſt the contrary muſt happen, when it produces the things that are uſeful to Mankind.

SECT. XXXI, XXXII. *Plants do not yield ſo much as they are able, and a Proof thereof ſhewn in Trees.*

MOSES adds farther in the ſaid 3d Chap. of *Gen. v. 17.* *in ſorrow ſhalt thou eat of it (the Ground) all the Days of thy Life.* And in the 19th. Verſe, — *in the Sweat of thy Face ſhalt thou eat Bread.* But we have touch'd upon this already in *Contempl. XX.* However, we ſee in theſe Places ſuch things foretold, which hitherto have been compleatly fulfilled ; and whereof, (unleſs the Cauſe be aſcribed to the aforeſaid Curſe) the univerſal and neceſſary Conſequence can never be proved by any Body : The rather, ſince this particular Curſe denounced a ſecond time againſt the Earth, on Account of the Murder of *Abel*, by his Brother *Cain*, is ſtill daily fulfilling in our Sight, *Gen. iv. v. 12.*

When thou Tillest the Ground, it shall not henceforth yield unto thee her Strength. Which may be inferr'd from the Structure of Trees and Plants, that seem to be made to yield incomparably more Fruit than we see them now do ; and which, by what follows, shall be undeniably proved.

I acknowledge, that it has been formerly objected to me as something very obscure, (when God was pleased to say to Man ; *Behold, I have given you every Herb bearing Seed, which is upon the face of all the Earth, and every Tree in which is the Fruit of a Tree yielding Seed ; to you it shall be for Meat*) How it could be possible, and be made to agree with the Plants and Trees, that they should have furnished to all Mankind the necessary Support and Food, in case Sin had not come into the World, and Men had thereupon continued Immortal, according to the Structure we observed above in their Bodies, which represents a compleat *Perpetuum Mobile*, or a Machine of an everlasting Motion. For tho' it had pleased God to have taken them after a while from the Earth (into which, as having not been revealed to us, we shall not here enquire farther) yet it seems to be very probable, that the Earth would have been incomparably more Peopled than now, when so many are so suddenly snatched away by Death.

But that which seems perfectly to solve this Difficulty, and yet more, to confirm the Curse of God, under which the Plants do likewise Groan, is the Structure of Trees, by which it appears, that unless there was something to hinder their Natural Fruitfulness from being exerted, very few of 'em would be able to Support a far greater Number of Men and Beasts, than is now done by a great many, according to our present Experience : To speak more clearly of this Matter, we see a powerful Example of the wonderfull Structure

ture of Trees ; forasmuch, as if the Branches of a Vine, and of several other Trees, whether cut off or growing still to the Mother Plant, when set in the Earth, will put forth both Roots and Branches ; as also, that the Roots of many such, as Plumb-Trees and others, will oftentimes raise a whole Wood of new Plants round about the Tree which they feed ; from whence the Strength of a Tree increasing its Fruits by new Plants, does manifestly appear. But not to treat of all in particular here, it is well known ; I. That each Branch of a Tree produces several Buds or Knots, II. That each of these Buds has also the Power and Faculty of still producing another Branch, which will likewise have its Buds or Fruits. III. These Buds must pass for so many Wonders with every one that rightly contemplates them ; forasmuch as each of 'em, if they be fitted thereto, will grow up to a large and perfect Tree, which again will yield thousands of other Buds and Fruits. The Modern Inoculation or Grafting of Trees, is a notable Instance thereof ; for in this Case, as it is well known, a little slice or bit of the Bark, in which there is a Bud contained, is thrust in between the Bark and Wood of another Tree, and so, if it grows, does commonly produce a perfect Tree : And to the end, that we may be ascertained, that such a Tree does only proceed from the said Bud, and not from the Trunk of that intowhich it was grafted, we need only observe, that the whole Branch will be of the same kind with that Tree from whence the Bud was separated ; nor shall we perceive one only Fruit or Leaf upon it that was peculiar to the Trunk. Thus, if an *Abricot* be Grafted upon a *Plumb*, a *Peach* upon a *Plumb* or *Abricot*, and a *Pear* upon a *Quince*, &c. there will only proceed an *Abricot* from the first, a *Peach* from the second, and a *Pear* from the third. Moreover we

are taught by the known Observations of Gardeners, that if the little Trunk of the Inoculated Bud be pluck'd off, and the Cavity that was made in the Bark remain unfilled up, the said Inoculation will not proceed, altho' the Tree should be strong enough. I will not now ask an Atheist, as one might justly do, whether any reasonable Man can imagine, that the Structure of these Buds (each of which comprise the whole Tree in little, and which Tree is produced, and as it were rolled out by the increasing and nourishing Saps) could be formed by Chance, and without a Wisdom which had in view the growth of Trees, Branches and Fruits? And for the farther Conviction of an Infidel, and to prove from the foregoing Remarks about Buds only, that Trees are capable of producing vastly more Fruits than we now experimentally find, we need only suppose, that the first Branch of a Graft will bear ten Buds in the first Year, and that each of those in the following Year will yield a Branch with ten Buds, and so on for twelve Years together, which is but a small part of the Years that many Trees attain to; there will be then found in the last or twelfth Year 1000,000,000,000; or a thousand times a thousand Millions of Buds upon the same Tree, each of which, according to the Nature of Trees, will produce one or more Fruits.

It must not be here objected against us, that such a Tree which produces Branches from all its Buds, would become a thick, close and confused Wood, insomuch that it would be able to yield no Fruit at all; because, besides that, no Body can tell how the growth or increase of Trees would have been, in case they had been free from the Curse, the Augmentation only of the length of the Branches between two Buds, would have solved the same. And if we should suppose, for
Argument

Argument sake, and for a greater Concession, that the three uppermost Buds of each Branch should only be Wood-Buds, and that the seven undermost should produce Fruit in their Season; there will be after this manner likewise Air and Room enough between every Branch of the Tree; which after having stood twenty Years, without reckoning the Fruits of the intermediate Years, would be able to yield in the 20th or last Year, a great many thousands of Millions of Fruits from so many Buds.

Yea, that at present there are innumerable Buds that remain useless and fruitless upon Trees, may be seen by lopping the most and greatest Branches of one that is strong and sound; at which time one shall see a vast Number of young Branches peeping out at several Places. Now that they cannot shoot out but at the same place where there were Buds first, may appear plain enough to any one that but takes the Pains of flitting a slender Branch through its Bud lengthwise, by which he will be convinced, that in the Buds only are the Passages through which the Wood-Fibres or Vessels can run outwards. Besides that, there may be many others that escape our Sight; as on both Sides, in the Seam of each Branch where it is fasten'd to the Wood, there are two Buds that few People have observed: Which, if the Branch be cut across, of the thickness of a Crown-piece, do almost always afford two Fruit Branches; or only one on that side of the Tree that the Person who cuts it has a Mind to produce it, especially if with his Knife he cuts away the other Bud. [See *La Quintinye, Part. IV. Cap. XVII, and XXI.*]

They that would be informed of something almost incredible concerning the Fertility of Trees, may consult the Transactions of the Royal French Academy,

Academy, for the Years 1700, and 1701, where he will likewise find the same proved as to Sorrel, Parsly, and other Garden-Stuff, by a Calculation made upon the Number of Branches and Sprigs, cut off from Trees and other Plants, and by counting the Seed found in each Branch thereof, and in particular the wonderful Fruitfulness of a Grain of Wheat, in many Ears exceeding the Number of those we commonly find produced thereby; but we have dwelt too long upon this Subject, and therefore shall pass forwards.

SECT. XXXIII. *Convictions from the foregoing Observations.*

To conclude; Let any one who has read the foregoing Sheets, and particularly what we have quoted from the *Transactions* of the *French Academy*, tell us, whether he be not convinced, that the Plants by their Structure are disposed to much greater Encrease than they really produce. Certainly the Gentlemen Members of the said *Academy*, who so diligently and nicely observe every thing, do own, that they are convinced and satisfied therewith, by ushering in a new Dissertation with these Expressions; *No Plant does ever arrive to its entire Perfection, in comparison of the Parts with which it is furnished.* [See the *Memoirs* 1701. p. 326.] From whence the foregoing Objection is solved; it appearing thereby, that altho' there were incomparably more Men in the World, the Plants would be more than sufficient for their Food, if they were as fruitful as they are capable of being by the present Structure of their Parts. And it is also true, that there must be a Cause or Power in Nature, whereby among so many thousand Plants, in so many thousand Years, there has been hardly one but what has been hinder'd from doing what

what it seemed to be made for, that is, from putting forth all the Buds contained in them, and the Fruit that should proceed from thence. Now let an Atheist or Infidel shew us the Reason and the Necessity why this Obstruction should have any place in Nature, notwithstanding that the Structure and Faculty of all Trees does unquestionably tend to the contrary. If any Body should pretend to ascribe this to any defect in the Sun, Air or Earth, it would be very probable, that in so many Climates and Soils there might at least one Tree have been found capable of exerting all that Fruitfulness to which its natural Structure had disposed it. But this not being so, any where, it must be owned, that the thing itself shews, that those who deduce it from the Curse of an angry G^{OD}, as his Holy Word has taught us, do furnish us with an Argument that gives the greatest Light to that which is, and would otherwise remain obscure to every Body, tho' it should not be allowed to be true. However, that which can be by no means denied, is, that that Sentence which was pronounced in the beginning of the World, has been hitherto undeniably and incessantly executed ; and that so illustrious a Man, who had so much Honour to lose, as the Writer of the Holy Scriptures, must have had more than a humane Certainty of what was afterwards to happen in Nature, who durst, with so much Assurance, foretell a thing that was likely to be opposed by all Men of Judgment and Understanding, from the beginning of the World to this time : For 'tis beyond all doubt, that so long as the World has lasted, every Man that has concerned himself in the leastwise in the Business of Agriculture, has exerted his utmost Diligence to find out Methods to increase the Fertility of all
useful

useful Plants, and to diminish the same in the hurtful ones.

SECT. XXXIV. *Of Sea-Plants.*

Now it seems proper that something should be said here about the Plants that grow at the Bottom of the Sea, of which they that would see a brief Account, may find it in the *Transactions* of the *French Academy* for the Year 1700. where it will appear like so many Wonders, to see them springing out of something that has no resemblance with Roots, and in Places entirely unfruitful; forasmuch as being formed of a smooth, flat, roundish Body, with Parts like Leaves, without any Appearance of Fibrous Roots, they adhere to Rocks, Stones and Shells, and other hard Bodies, thro' which there does not seem the least Sap to be conveyed for their Nourishment. Mr. *Tournefort* reckons up four several Kinds of this Sort of Plants in the abovemention'd place.

Now that which is to our purpose in this Matter, is, that in order to convince those that deny the Divine Perfections, that Plants are neither produced by Chance, nor by any ignorant necessary Causes, the great Creator thereof has been pleased to shew hereby; *First*, That whereas all other Plants seem absolutely to require to live in Air, his unlimited Power, which only operates according to the Council of his own good Pleasure, will not be bound by such Laws; causing for that very End certain Plants to grow and live in the deepest Bottom of the Sea, where all others would certainly dye. And, *Secondly*, to shew, that mere Chance can have no place here, he has furnished them with all the Instruments that are requisite for the Growth, Production, and farther
Structure

TAB. XVIII.

Fig. 1

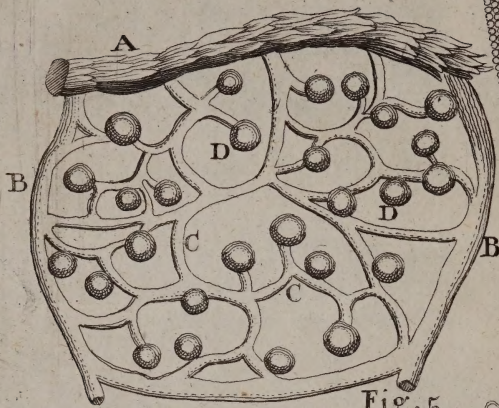


Fig. 5

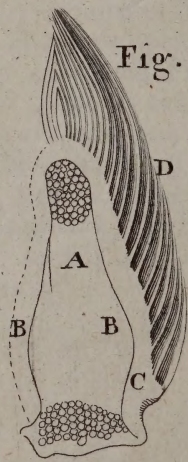
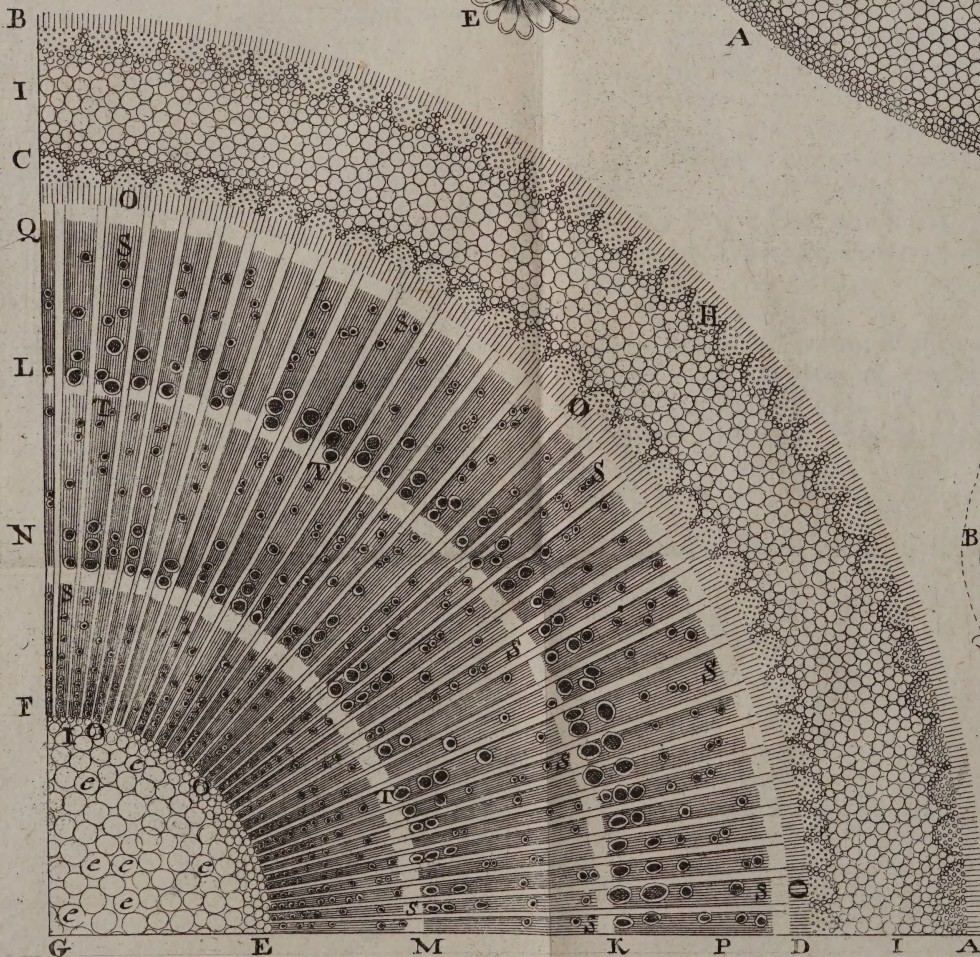
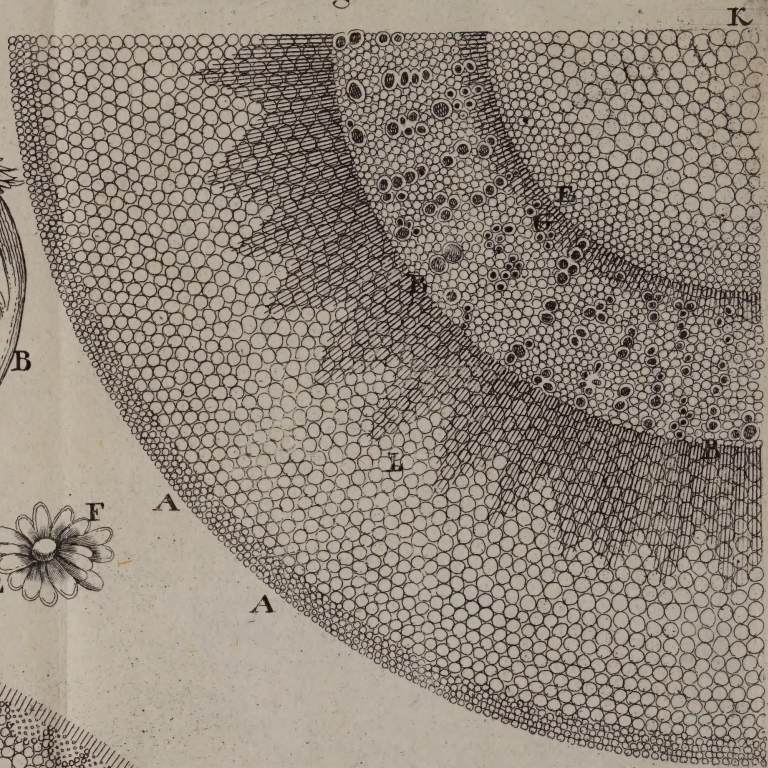


Fig. 3



Fig. 4

Structure of a determinate Sea-Plant. The same Proof has been likewise used above in the Comparison between Fishes and other Animals that live in the Air ; and it appears from both, that this Wisdom is not confined either to Number, forasmuch as the Fishes and Sea-Plants are innumerable ; nor to Kind, since there is so great a variety of both ; but that it does all things for its own Glory, and in Conformity to its own Pleasure.

SECT. XXXV. *Convictions from all that has been said above.*

Now to draw a Conclusion from all this, and to see what those Mathematicians, who stand in the first Rank among the Enquirers into Nature, have thought upon these Matters, we cannot do better than to quote the Expressions of Mr. *Huigens* in his *Cosmotheoros*, p. 18, and 19. No Body, I think, will deny that there is something greater and more wonderful in the Structure, Life, Manner of Growth, and Production of Plants and Animals, than of lifeless and insensible Bodies ; tho' these latter may be more remarkable for their Magnitude, such as Mountains, Rocks, Seas, and the like. Moreover, in both those kinds of Animate things, the Glory of the Divine Providence and Wisdom appears much more differently and eminently. For tho' a Disciple of *Democritus*, or of *Cartesius*, should perhaps say, that in order to shew how every thing that we see both in Heaven and Earth has acquired its Existence, nothing more is necessary than Atoms or little Particles of Matter and Motion ; yet he will in vain endeavour to apply the same to Plants and Animals, nor be able to bring any thing probable from their first Existence and Structure. Since it appears but too plainly, that such things can never proceed from a simple and accidental Motion of Bodies, forasmuch as all things
are

are found therein to be adapted to certain Ends and Purposes, with the utmost Foresight and penetrating Knowledge of the Laws of Nature and Mathematicks; to say nothing of the Wonders of their Production.

I thought this Passage, of which kind I could have produced many more from great and good Philosophers, very proper in this Place; *First*, Because an unhappy Atheist might learn from hence how vain that Expectation is wherewith many of 'em are wont to flatter themselves, namely, that Men of the greatest Judgment have entertained the same Sentiments with them: Since we here meet with so famous a Naturalist, and one so highly esteemed by the learned World, with whom few of these Infidels can have the Confidence to compare themselves, speaking after a manner entirely different from their ill-grounded Opinions of the Divine Wisdom and Providence. *Secondly*, Because what we have just now quoted shews, with how much reason Atheism ought to be suspected by itself of Error and Falsity, since we see such great Mathematicians openly acknowledging that which an Infidel must deny, if he would quiet his own Mind. *Thirdly*, Every one that has read this Book of Mr. *Huigens*, must likewise own, that he does therein make a very careful Difference between what can be proved *True*, and that which is *Uncertain*, and can only pass for simple *Conjecture*: Since this great Mathematician expressly declares, that he would not have several of the Opinions which he there proposes, to be received for more than Guesses and Uncertainties.

Now let an Atheist examine himself, whether he can by far alledge so much Probability for his Sentiments, as is to be found in these Conjectures, and let him compare the one with the other.

This

This worthy Author (that we may carry the Comparison yet farther) lays down in his *Cosmotheoros* some settled Mathematical Truths, and which Experience has render'd certain; and shews how his Conjectures may be made to agree therewith: Now what has an Atheist ever done like this, who never could advance any other than his own simple Notions for a Foundation to his Sentiments?

Moreover, if Mr. *Huigens* supposes, that it cannot be proved to be impossible in Nature, that there is Land and Sea-Animals, Plants, and the like in the Planets; he shews likewise, by an undeniable Experience, that something analogous is found upon this Globe. On the contrary, an Atheist maintains, that such surprising Masterpieces, as Animals and Plants are produced by Chance, at least, without the Wisdom of the Maker; in which, however, so many well adapted Instruments, and so many different Motions, all serving to the same Purpose, are to be seen: Notwithstanding which, he has never yet been able to shew any thing like them in Works of much lesser Skill and Artifice, such as Watches, Mills, or even in the simple Structure of Houses, and Chambers, which for the Number of Instruments and multiplicity of Motions, fall infinitely short of any living Creature or Plant.

Finally, Notwithstanding all these things, this Gentleman confesses all his Speculations to be no more than Conjectures; whilst the Atheist, that cannot advance near so far, and who has the analogous Experiments perfectly against him, will have his Notions pass for irrefragable Truths, even with the Danger of everlasting Misery.

The End of the Second Volume.

ERRATA.

Page 376, Line 25, for is that the subsiding of the Water with an infinite, &c. read, that at the subsiding of the Water an infinite, &c.

Page 494, near the Bottom, put a (.) at Zaire, and dele the (;) after America.

Page 563, Line 28, insert the Word in.

Page 568, Line 28, put in a Parenthesis (who imagine they understand every thing.)

Page 569, Line 5, &c. read, Wherefore if one suppose, that the Earth is not perfectly Globular, but that its Equatorial Diameter is longer than that which may be drawn from the North Pole to the South, and that all the Diameters from the Pole to the Equator do continually increase in Length, &c.

Page 575, Line 13, &c. read, Or remains always parallel to it self, as in the fifth Figure; and in this Manner the Earth, without any Support, does always preserve the same Obliquity, and Parallellism of its Axis, at least to such a Degree, that the Astronomers, &c.

Page 585, Line 3, for it is, read it is not.

Page 586, Line 9, for Oppressors read Opposers.

Page 590, Line 25, for the last Degree of the Earth's Breadth, read the last Degree of Latitude.

ERRATA

Page 170. Line 1. It is that the longitude of the
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